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THE PHYSICAL AND ECONOMIC BASES UPON WHICH TO DEVELOP SYSTEMS OF LIVE STOCK FARMING IN THE U. S.

BY

CHARLES HACKETT DENSON

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Charles Hackett Denson

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H. P. Rusk
Instructor in Charge

APPROVED Herbert W. Mumford

HEAD OF DEPARTMENT OF Animal Husbandry

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I. LAND RESOURCES OF THE UNITED STATES

The greatest natural resource of the United States is its vast area of arable land. No other one country is better situated with regard to soil, climate, rainfall, and other conditions favorable to agriculture. The total land area of the United States, exclusive of its outlying possessions, constitutes approximately 37 percent of the North American continent and 5 percent of the land surface of the earth. Not all of this land is in farms nor is all of this vast territory capable of producing crops. The following table* will give some idea of the importance of the land resources of the United States:

Number of farms	6,361,502
Land area of country (acres)	1,903,289,600
Land in farms (acres)	878,789,325
Improved land in farms	478,451,750
Unimproved land in farms	400,346,575

The area of the land in farms in 1910 was 46.2 percent of the total land area of the country, and the improved land in farms was 54.4 percent of the farm area and only 25.1 percent of the land area of the country was improved farm lands. Each Census report shows a decided increase in both the number of farms and the land in farms. This is well illustrated by the Census reports from 1850-1910 as given in the following table:

	Land in Farms	Number of Farms
1910	878,789,325 acres	6,361,502
1900	838,591,774 "	5,737,372
1890	623,218,619 "	4,564,641
1880	536,081,835 "	4,008,907
1870	407,735,041 "	2,659,985
1860	407,212,538 "	2,044,077
1850	293,560,614 "	1,449,073

The increase in the number of farms since 1850, as reported by the

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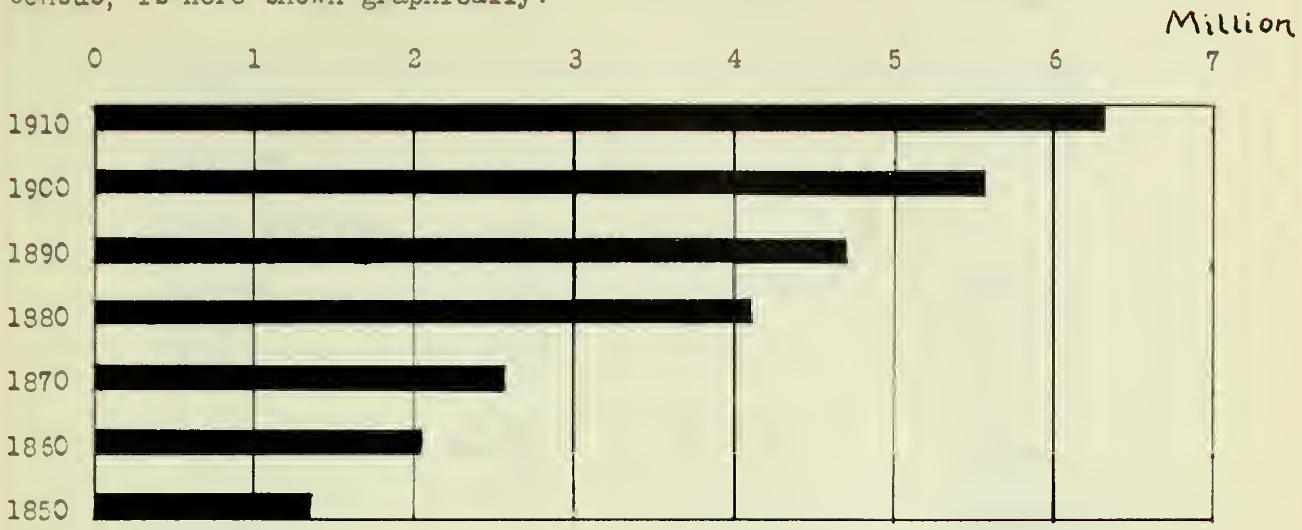
*1910 Census

Census, is here shown graphically:



II. POSSIBLE INCREASE IN FARM AREA

The area of land in farms in 1910 was 878,789,325 acres or 46.2 percent of the total land area of the country. Just how much of the remaining one billion acres will ultimately be added to the farm area can not be determined accurately. So many factors have to be considered in making an estimate. New lands are being added while older and less productive lands are being abandoned, thus complicating any attempt at an accurate estimate of the proportion of the land area that will be ultimately in farms.

The increase in land area for agricultural purposes in the future will come primarily from three sources, namely, swamp lands, irrigated lands, and semi-arid and arid lands.

The Department of Agriculture* estimates that the reclaimable swamp lands in the United States amount to 78,475,833 acres. Some other authorities** estimate that along the Atlantic coast alone there are 80 million acres of these swamp lands which, if drained, would support ten million people, allowing 40 acres to the family of five. The states with large areas of swamp land are as follows:

* Senate Document 443

** Principles of Rural Economics - Carver P 140

Delta Swamps	Acres
Florida	18,560,000
Louisiana	9,600,000
Mississippi	6,173,000
Arkansas	5,760,000
North Carolina South Carolina Alabama Georgia Texas	1,000,000 - 2,400,000

Glacial Swamps	Acres
Michigan	4,400,000
Illinois	2,688,000
Minnesota	4,500,000
Wisconsin	2,500,000
California Indiana Missouri	1,000,000 - 2,000,000

The total area of swamp lands in the United States is equal to the combined areas of Ohio, Indiana, and Illinois. Many of the states have practical drainage laws which permits drainage districts to be formed and as a consequence vast areas of swamp lands are being drained and brought under cultivation. It is estimated* that 150,000,000 acres of swamp lands already in cultivation could be improved in productivity twenty percent by drainage alone. This would be equivalent to the addition of 30,000,000 acres of swamp lands to the improved farm area. Thus we have a possible addition of 110,000,000 acres of swamp lands to the improved farm area.

These swamp lands as a rule are very fertile. Most of these lands are very rich in nitrogen and organic matter but in some cases they are deficient in phosphorus and potassium, however, upon the whole they compare very favorably**

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*Country Gentleman - Nov. 15, 1913. Senate Document 443

**Conservation of Natural Resources. - Van Hise. P. 347

with the average corn belt lands. These lands are well adapted to growing practically all the field crops and many of the vegetable and fruit crops. Swamp lands are especially well adapted to growing corn and rice, the yields of corn* being from 50 to 100 bushels per acre under good tillage.

III. IRRIGATED LANDS

The amount of land irrigated in 1909* was 13,738,485 acres. Irrigation enterprises were capable of irrigating 19,334,697 acres in 1910 and the acreage included in projects was 31,111,142 thus making 50,445,839 acres of irrigated land including projects. It seems altogether probable that ultimately 75,000,000 acres of land will be brought under irrigation. Some authorities** estimate that ultimately 20,000,000 people will be supported on irrigated land. This is a very optimistic estimate however and a more conservative estimate*** it seems, places the figure at 60,000,000 acres capable of supporting 10,000,000 people.

Irrigated lands are fertile yet it must be kept in mind that the fertility must be maintained if they are to continue productive. With large use of turbid waters, there is always soil enrichment but reservoir water adds little or no fertility to the soil as shown by the low yield of irrigated lands in India. In his Handbook of Indian Agriculture, Mukerji makes the following statement:

"The best crops of wheat are grown on lands newly brought under canal irrigation. Where canal water is used for irrigation for a number of years, the outturn is found to fall off even below the original level. No manure is required for dearh land which is annually renovated with silt".

The fertility of the irrigated lands can be maintained by the application of mineral fertilizers and growing legumes such as alfalfa which is well adapted to this type of lands. It can be said in general that irrigated lands are well

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*Thirteenth Census. Vol. V. P. 846.

**Conservation of Natural Resources. - Van Hise. P. 189-190

***Soil Fertility. - Hopkins. P. 583.

[illegible]

[illegible]

[illegible]

[illegible]

adapted to growing all field crops and especially those requiring an abundance of moisture.

IV. ARID AND SEMI-ARID LANDS

The western arid region occupies about two-fifths of the United States or an area of approximately 768,000,000 acres. A very large percent of this vast area is not suited to agriculture. Just what portion will finally be brought under cultivation is rather speculative. While some authorities* have estimated that ultimately 400,000,000 acres of this area will be made to produce crops and livestock, it is more probable that one-half of this amount or 200,000,000 acres is nearer the correct estimate.

These lands will have a more important economic value in the future. As lands in this section are brought under irrigation, the adjacent lands have a greater economic value in that they can produce livestock to consume the unmarketable crops produced on the irrigated lands and thus convert unsalable crops into livestock products which find a ready market. During the period from 1876 to 1885, the precipitation was above normal and good crops were produced in the dry farming area. During the next 15 years, 1886-1901, the precipitation was below normal and crops failed. These lands are not well adapted to general farming but are better suited to growing drouth resisting crops such as the grain sorghums. Kaoliang, great millet, is well adapted to this region and requires only about one-third** as much water to produce a pound of grain as northwestern dent corn. The yield of grain in this section is generally from 10 to 20 bushels per acre. A large percent of this vast area is too rough or lacks sufficient annual rainfall for cultivated crops but will have some economic value in producing livestock - sheep and cattle - for consuming the rough feeds grown on irrigated lands and in

*Conservation of Natural Resources. - Van Hise. P. 190

**Agricultural Economics. - Nourse. P. 152 - 153.

furnishing feeders for the Corn Belt.

The unimproved land in farms in 1910 was 400,346,575 acres. It is impossible to calculate accurately what portion of this will be added to the improved farm area but it seems conservative to say that we may expect to add 200,000,000 acres of this area to the improved lands. This will come slowly but certainly as the demand for land increases and food crops become relatively scarcer. To this we may expect to add about 100,000,000 acres of swamp land, 40,000,000 acres of irrigated land, and 200,000,000 acres of semi-arid land, making a total of 540,000,000 acres to be added to the present improved farm area or in other words we will be able to ultimately double our present improved farm area. If this expectation should be realized, we would have then only approximately 50 percent of the land area of the country in improved farms. This seems very conservative as compared to many of the European countries such as England, France, and Germany that have from 65 to 80 percent of their land area in improved farm lands.

V. CROP PRODUCTION

To feed the coming generations and the constantly increasing population, there must be not only increased cultivated areas but greater efficiency in producing crops. This greater efficiency will be brought about in a number of ways, namely: through soil conservation and improvement; better cultivation; seed selection and better varieties; crop selection and adaptation; and improving permanent and rotative pastures which makes possible the production of more livestock. The successful operation of these fundamental factors constitutes good management or efficiency in crop production.

VI. SOIL CONSERVATION AND IMPROVEMENT

A nation's greatest asset is the soil. Many people have the idea that nature makes the soil richer year by year and that we as a people need not have

any fear that the time will ever come when there will be a scarcity of fertile soil on which to produce food. Nature dissolves out calcium and leaves an acid soil; slowly but surely dissolves out the mineral elements and leaves the soil deficient in phosphorus and potassium. There is an accumulation of organic matter for a time, but there comes a time when soils begin to lose nitrogen and organic matter. There seems to be no immediate danger of a scarcity of good soils in the United States for crop production, yet should the farmers go along heedless of the many factors that tend to lessen soil fertility and lower crop yields, the time will surely come when the crops produced will not be sufficient to feed the increased population.

It has been demonstrated many times over and in widely separated localities that this depletion of the soil can not only be prevented, but the original fertility restored, and in many instances actually be increased. Some of the chief causes of the loss in soil fertility are erosion, continued cropping, and leaching. Level lands are little affected by erosion but on the rolling lands it is a more serious factor. Erosion may actually increase the phosphorus and potassium, but it greatly depletes the supply of nitrogen and organic matter. In five years' experience in extension work in the field the author has found the following methods very practical in largely preventing soil erosion:

(1) Using soil binding plants.
(2) Increasing the supply of organic matter
(3) By tile drainage.
(4) Terracing.

A combination of the above methods suggested is very efficient in preventing soil erosion. The plant food removed by continued cropping should have due consideration by the farmers. A 100-bushel corn crop removes 148 pounds of nitrogen, 23 pounds of phosphorus, and 71 pounds of potassium; a 100-bushel crop of wheat removes 192 pounds of nitrogen, 32 pounds of phosphorus, and 116 pounds of potassium. It is thus apparent that continued cropping would finally rob the

soil of its fertility. The annual loss from leaching* further robs the soil of 10 to 50 pounds of nitrogen, 1 to 2 pounds of phosphorus, and 5 to 10 pounds of potassium. The most practical and economic way to supply the nitrogen and organic matter lost, is by growing the high yielding legumes and the application of farm manures. To maintain soil fertility and a permanent agriculture with a good system of livestock farming, it would be necessary to apply about two tons of ground lime rock, and 1,000 pounds of 14 percent phosphate rock every five years. Soils deficient in potassium, would need some potash salts applied annually. Quite often only one of the elements is the limiting factor and greater crop yields can be secured at small cost by supplying the limiting factor.

That a high state of productivity of the soil can be maintained without the use of purchased fertilizers is shown by results obtained at the Illinois Experiment Station. The soil was typical brown silt loam and the experiment was with corn every year, corn and oats, and corn, oats, and clover. Below are the averages for 13 years and 29 years:

Crop System	13-year Experiment	29-year Experiment
Corn every year	35 bushels	27 bushels
Corn and oats	62 "	46 "
Corn, oats, and clover . . .	66 "	58 "

The soil in its virgin fertility produced 70 bushels per acre. Continuous cropping to corn for 13 years reduced the yields to 35 bushels and in 29 years to 27 bushels. A rotation of corn, oats, and clover maintained the yields for 13 years within four bushels of the original and had decreased only 12 bushels in 29 years.

The results of another** experiment in southern Illinois with legumes supplemented by lime, phosphorus, and potassium gave increased yields of both

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*Soil Fertility and Permanent Agriculture. - Hopkins. P. 259.
**Thorne - Farm Manures. P. 215.

wheat and corn, with results as follows:

Treatment	Wheat Yield	Wheat Increase	Corn Yield	Corn Increase
None	3.9 bu.	- - - -	36.4 bu.	- - - -
Legume	7.8 "	3.9 bu.	39.7 "	3.3 bu.
Legume, lime	15.4 "	11.5 "	53.3 "	16.9 "
Legume, lime, phosphorus	17.2 "	13.3 "	49.2 "	12.8 "
Legume, lime, phosphorus, and potassium	20.8 "	16.9 "	47.4 "	11.0 "

It will be observed that the wheat increased from 3.9 bushels on the plot receiving no treatment to 20.8 bushels on the plot receiving a legume, lime, phosphorus, and potassium or an increase of 16.9 bushels. With the corn the results were also very marked. The plot receiving no treatment produced 36.4 bushels and the plot receiving only lime in addition to the legume produced 53.3 bushels or an increase of 16.9 bushels. A great deal of data has been obtained by the experiment stations throughout the country on the value and importance of crop rotations in maintaining soil fertility. The oldest experiment field in the United States is located at the University of Illinois. On part of the field, corn has grown on the same land every year since 1879; on another part corn and oats have been grown alternately; and on a third part, corn, oats, and clover have been grown in a rotation. These are known as the Morrow Plots. On an adjoining tract of land, fifty additional experimental plots were laid out by Eugene Davenport in 1895, these being known as the Davenport Plots, and a five-crop rotation system with corn, oats, clover, wheat, and alfalfa was established. Careful and accurate data has been kept of the crops grown on these plots thus making the results quite trustworthy.

VII. ILLINOIS EXPERIMENTS*

Acre-Yields from Morrow (M) and Davenport (D) Plots

Serial plot No.	Soil Treatment	10-year average Corn Bu.	10-year average Oats Bu.	1906-1915 Clover Tons	5-year average Wheat Bu.	4-year average Alfalfa Tons	Average acre-value
M 3	None	28.8	- -	- - -	- -	- - -	$14.40
M 4	None	37.5	38.0	- - -	- -	- - -	16.98
M 5	None	57.6	33.4	1.69	- -	- - -	19.69
D 1	None	55.5	44.4	1.93	22.2	- - -	21.75
D 1	None	55.5	44.4	1.93	22.2	3.23	23.86
D 2	Residues	56.9	47.5	(1.81)	23.5	2.93	23.67
D 3	Manure	68.4	52.0	2.08	24.8	2.80	25.72
D 4	R L	61.5	49.7	(1.93)	25.0	3.11	25.21
D 5	M L	71.7	53.9	2.34	28.1	3.79	29.36
D 6	R L P	77.0	62.3	(2.44)	39.1	5.03	35.44
D 7	M L P	79.5	63.2	3.04	38.3	4.98	36.71
D 8	R L P K	77.6	62.3	(2.19)	38.2	4.93	34.62
D 9	M L P K	79.5	63.3	3.88	37.3	5.02	36.67

On the Morrow Plots, with corn continuously and no restoration of fertility, the acre-value of the produce, as a ten-year period, was $14.40, $16.98 where corn and oats are alternated, and $19.69 where corn, oats, and clover are rotated, this being the value of corn computed at fifty cents per bushel, oats at forty cents per bushel, and alfalfa hay at $10.00 per ton. It is a very significant fact that the yield of corn in the corn, oats, and clover rotation was exactly double that on plots growing corn continuously. These average yields are not altogether comparable because corn is not grown every year in the corn, oats, and clover rotation on the Morrow Plots. However, corn is represented every year on the Davenport Plots, where the average yield for the ten-year period, with no restoration of fertility, was 55.5 bushels compared with 57.6

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*Illinois Circular No. 193

bushels on the Morrow Plots.

The Davenport Plots include five series of ten plots each. The results on these plots show, that with no soil treatment, good yields have been maintained, the average yield of corn on series D 1 being 55.5 bushels, oats 44.4 bushels, wheat 22.2 bushels, clover 1.93 tons, and alfalfa 3.23 tons. On the plots (series D 6) receiving residues, lime, and phosphorus, the average per acre yields were as follows: corn 77.0 bushels, oats 62.3 bushels, wheat 39.1 bushels, clover 2.44 tons, and alfalfa 5.03 tons.

Acre Yields From Plots on the University South Farm***

Eight-year Average 1909-1916

Rotation	Wheat - corn oats-legume	Corn - corn - oats legume		Corn - corn - corn -legume		
Treatment	Corn	1st corn	2d corn	1st corn	2d corn	3d corn
Residues, Phosphorus	61.4 bu.	56.3 bu.	52.0 bu.	48.5 bu.	43.7 bu.	37.8 bu.
Residues	51.9 "	49.2 "	47.0 "	43.4 "	40.1 "	32.3 "
Organic matter, P.	64.9 "	55.1 "	53.0 "	49.4 "	45.0 "	38.2 "
Organic matter	55.1 "	50.6 "	47.1 "	45.2 "	41.4 "	31.7 "

These results show that good crop rotations are very important in helping to maintain crop yields. The fertility of the soil can be maintained, in some cases increased, by a good system of crop rotation, and the addition of ground lime rock and phosphorus together with the residues from the crops raised. "By a good system of farming the crop yields in the United States should be increased 50 percent"*. The average yield of corn in Champaign County, Illinois, is approximately 45 bushels per acre, and yet, a number of farmers** are producing 70 bushels of corn per acre by using good systems of farming. Thus it seems possible to increase crop production 40 to 50 percent through maintaining and increasing soil fertility here in the corn belt where the soil is yet comparatively rich in virgin fertility. In the South where the average yield of corn is from

*Dr. Hopkins - In a lecture before his class.
**Illinois Circular No. 149 ***Illinois Circular No. 193.

20 to 25 bushels per acre, and where such winter legumes as burr and crimson clover, vetch, and field peas can be worked well into the rotation, there is still greater possibility of increasing crop yields through maintaining and increasing soil fertility with a good system of farming.

VIII. CULTURE

Factors of great importance in crop production are a thorough preparation of the seed bed, methods of planting, and cultivation. A thorough preparation of the seed bed is very essential with practically all crops. In preparation for corn, the land should always be broken with turning or disk plows as they turn the organic matter under where it is out of the way of cultivation. It is not always necessary to plow the land for small grains especially when seeding after cultivated crops. It generally gives better results, however, to plow the land, provided it can be done long enough in advance of the seeding. The best time to plow the land for corn is in the fall, unless there is a cover crop of some promise. The main advantages of fall plowing are:

(1) Hastens the decay of organic matter
(2) Aids in the control of insects
(3) Exposes the roots to the weather which kills biennial and perennial weeds
(4) Gives a better distribution of labor
(5) Freezing aids in pulverizing the soil.

The results from fall and winter plowing are shown in the following tables:

Table I*

Field	Time of plowing	Yield of corn - bu. per Acre.
A	September 25, 1895	75
A	April 2, 1896	56
B	September 10, 1895	75
B	April 15, 1896	55
C	November 1, 1896	32
C	April 8, 1897	30

*Nebraska Bulletin No. 54

Table II*

Time of Plowing	Average Yield (1900-1904) of wheat	
	Grain - Bushels	Straw - Tons
July 15	27.10	1.39
August 15	24.20	1.19
September 15	22.00	1.15

The depth to plow for corn, and wheat was determined at the following Experiment Stations**:

Station	Depth of plowing - inches				
	2	4	6	8	10
Illinois	52.9	69.4	69.3	71.7	
Indiana (ave. 3 yrs.)		39.5	40.5	42.3	41.8
Pennsylvania (ave. 3 yrs.)		47.0	62.0	57.5	58.5
Alabama (Canebrake Sta.)		24.1			24.1
Minnesota		65.8	64.4	59.5	
Ohio		43.1		42.9	
Nebraska		38.5		31.0	

The proper depth to plow seems to be from 6 to 8 inches.

The method of preparation for wheat***

	Yield in bushels per acre.
Disked, not plowed	6.63
Plowed September 15, 7 inches deep	14.15
Plowed August 15, 7 inches deep	22.19
Plowed July 15, 7 inches deep	27.11
Listed July 15, 5 inches deep, worked down . .	22.77

In the states where small grains are planted in the spring, the best method of preparing the seed bed is with the disk harrow. The work can be done more rapidly with a disk harrow, but there is practically no difference in the

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*Oklahoma Bulletin No. 65
**Hunt - Cereals in America P. 220.
***Kansas Bulletin No. 185

yields as shown from the experiments at the following experiment stations:

Station	Bulletin	Yield of Grain (bushels)		Number of Tests.
		Spring Plowed	Prepared without Plowing	
Illinois	23	36.1	39.1	2
Kansas	74	27.4	24.0	5
Minnesota	40	79.3	82.5	1
Ohio	138	52.8	48.7	6

These results bring out the facts that the land should be plowed 6 to 8 inches deep in the fall for maximum crops of corn, in July for the best yields of fall grains, and, that for spring grains, the preparation should be done with the disk harrow.

There are two general methods of planting corn, namely, checking, and drilling. There is no special advantage in the one method over the other from a yield standpoint, however, there is a distinct advantage in checking as this method makes it possible to give cross cultivations. The time of planting, however, is of very great importance as shown by the following results obtained at the Illinois Experiment Station*:

Date of Planting	Bushels per acre - Air dry 6-year average.
April 22 - 26	48
April 27 - May 4	60
May 4 - 11	62
May 11 - 18	62
May 19 - 25	61
May 26 - June 1	56
June 1 - 8	50
June 8 - 15	39

These results show that the best average date to plant corn in central Illinois is from May 4 - 25. These results emphasize the importance of planting corn at the proper time.

*Illinois Bulletin No. 20.

In seeding the small grains, drilling is a much more satisfactory method than broadcasting. Drilling has the following advantages:

(1) The seed are planted at a uniform depth in moist earth.

(2) The drill furrows catch snow, and protect the plants from the effects of heaving.

(3) Drill furrows catch soil particles being blown by winds.

Drilling gives better yields as shown by results of drilling and broadcasting wheat at the Illinois Experiment Station.

Method of seeding	Yield per acre (5-yr. ave.)
Drilled 1 inch deep	28.7 bushels
Drilled 2 inches deep	28.7 "
Drilled 3 inches deep	28.5 "
Sown broadcast	24.9

Drilling is the best method of seeding oats as shown by a summary of methods of seeding oats at Urbana (Illinois Experiment Station):

Method of seeding	Amount of seed per acre	Yield per acre	No. trials
Broadcast	2 bushels	40.6 bushels	35
Drilled	2 "	47.5 "	35
Broadcast	3 "	40.9 "	38
Drilled	2 "	44.7 "	38

Drilling at the rate of 2 bushels per acre gave approximately four bushels better yield than broadcasting at the rate of three bushels per acre. The proper rate of seeding, in the case of wheat, is six pecks per acre, and for oats eight pecks per acre. There is no advantage to be gained by heavier seeding except, possibly, when intended for pasturage or for soiling purposes.

Cultivation is a factor of great importance. With small grains, especially fall seeded grains, the cultivation should be done with a corrugated roller. Some conclusive results on harrowing and rolling winter wheat were obtained by the Nebraska Experiment Station, and also the effect of spring cultivation of

winter wheat by the Montana Experiment Station. The results at the Nebraska Station were as follows*:

Method of planting	Cultivation	4-year average yield
Drilled	Harrowed in spring	37.0 bushels per acre
Drilled	Not harrowed	38.2 " " "
Broadcast	Harrowed in spring	35.3 " " "
Broadcast	Not cultivated	38.3 " " "
Drilled	Harrowed fall and spring	37.8 " " "
Drilled	Rolled in spring	43.3 " " "
Drilled	Rolled and harrowed in spring	40.0 " " "

Conclusions from bulletin:

"The results from rolling were conclusive. In no year did it fail to give an increased yield, the average increase being 5.1 bushels per acre".

There was no benefit derived from harrowing, but in some cases considerable loss resulted. The results at the Montana Station** were as follows:

Year	Not harrowed	Harrowed in spring	Rolled in spring.
1911	19.07 bushels	17.27 bushels	
1912	23.00 "	23.40 "	23.00 bushels
1913	36.00 "	29.00 "	41.00 "
Average	26.02 "	23.22 "	32.00 "

The results at both stations show an average gain in yield from rolling of approximately five bushels. There seems to be no reason why other fall seeded small grains would not be benefitted by spring cultivation with the corrugated roller.

With intertilled crops - corn, potatoes, cotton, and other crops - the cultivation is of relatively more importance. The purposes of cultivation of intertilled crops are:

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*Nebraska Press Bulletin No. 30.
**Montana Bulletin No. 100.

(1) To control weeds
(2) To aerate the soil
(3) Conserve moisture
(4) To encourage nitrification.

The earlier types of cultivators were constructed for deep cultivation which was very injurious to the crops. This point is illustrated by the following experiment which shows the results of deep and shallow cultivation:

Depth of cultivation	Average 8 years
2 inches	42.36 bushels of corn per acre
3 inches	42.56 " " " " "
4 inches	37.92 " " " " "

Cultivation to a depth of two to three inches is sufficient to destroy weeds which is the main purpose of cultivation in humid sections. Cultivating four inches deep reduced the yield 4.5 bushels.

The importance of the cultivation of corn is very outstanding from results at the Illinois Station*:

Plot No.	Soil Treatment	1906	1907	1908
1	Land not plowed, not cultivated, weeds clipped at surface		38.3 bu.	32.3 bu.
2	Land plowed, well prepared, not cultivated, weeds clipped . . .		44.0 "	39.6 "
3	Land plowed, well prepared, nothing done after planting	None	None	4.4 "
4	Land plowed, well prepared, well cultivated	44.7 bu.	49.6 "	29.4 "

It is apparent from these results that, on good land in humid sections, the greatest benefit of cultivation is due to the killing of weeds. The yield on Plot 3, where the land was well prepared but nothing done after planting, was nothing in 1906 and 1907, and only 4.4 bushels in 1908. Plot 4, which was well

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*Hopkins - Soil Fertility and Permanent Agriculture. P. 578-9.

prepared and cultivated, produced 44.7 bushels in 1906, 49.6 in 1907, and 29.4 bushels in 1908. For soils deficient in nitrogen, frequent cultivations will hasten the decay of organic matter, encourage nitrification, and possibly increase crop yields. On the worn hill soils at Ithaca, New York, the Cornell Station has shown very beneficial results from the long continued cultivation of potatoes. But the question still remains if more clover plowed under would not have given better yields at less expense, and left the land in better condition for the succeeding crops.

IX. SEED SELECTION AND VARIETIES.

The degree of perfection which has thus far been attained with crops and their adaptation to changed conditions has been brought about, mainly, through careful selection from inferior specimens. Greater care in selecting and grading seed will result in further improvement over what we have at present. Certain varieties of crops yield better than others, and are better adapted to peculiar local conditions existing in some sections. The Illinois Experiment Station has conducted tests to determine the best yielding varieties of corn, wheat, and oats for northern, central, and southern Illinois. The following results were obtained*:

Average yields of varieties grown at DeKalb (1907-1915)

Western Plowman used as a standard variety of corn.

Variety	Percentage rating of varieties	Average bushels per acre.
Western Plowman	100.0	63.9
Reid's Yellow Dent . . .	93.1	57.9
Funk's 90 Day	91.2	58.3
Leaming Low Ears	78.1	49.9
Leaming High Ears	64.9	41.5
Silvermine	76.6	58.0

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*Illinois Bulletin No. 191.

Yields of corn varieties at Urbana, using Reid's Yellow Dent as a standard. (1901-1915)

Variety	Percentage rating of varieties	Average bushels per acre
Reid's Yellow Dent	100.0	62.0
Boone County White	97.3	60.3
Leaming	95.5	59.2
Champion White Pearl	94.4	57.6

Yields of varieties of corn grown at Fairfield, percentage rating using Funk's 90-day as a standard (1907-1915)

Variety	Percentage rating of varieties	Average bushels per acre
Funk's 90-day	100.0	41.0
Reid's Yellow Dent	97.1	39.8
Champion White Pearl	89.3	36.6
Silvermine	89.3	36.6
Leaming Low Ears	83.2	34.1

As may be seen in looking over these tables, the most important varieties of corn grown in Illinois have been compared. Some of the other varieties tested, did not yield nearly so much in comparison with these best varieties. These results show that Western Plowman is the leading variety for Northern Illinois, Reid's Yellow Dent for Central Illinois, and Funk's 90-day the leading variety for Southern Illinois. There was a difference of 22.4 bushels between the best yielding and poorest yielding of the six best yielding varieties tested at DeKalb; 4.4 bushels between the highest and lowest yielding of the four highest yielding varieties tested at Urbana; 6.9 bushels between the best yielding and lowest yielding of the five best yielding varieties tested at Fairfield.

There is also a wide difference in variety yields of oats. Average yields of oats grown at DeKalb from 1907-1916 are as follows*:

Variety	Percentage rating	Average yield (1911-1916)
Swedish Select	100.0	56.4 bu. per acre
American Banner	108.3	61.1 " " "
Schoenen	112.2	63.3 " " "
Silvermine	113.5	64.0 " " "

This shows a difference of 7.5 bushels between Swedish Select and Silvermine. The percentage ratings and yields of oats at Urbana (1903-1916) are as follows*:

Variety	Percentage rating	Average yield (1905-1916)
Sixty-day	110.6	58.1 bushels
White Bonanza	102.2	
Siberian	100.0	52.5 "
American Banner	95.9	47.0 "

This shows a difference of approximately 15% in percentage ratings between Sixty-day and American Banner, and a difference of 11.1 bushels in favor of the Sixty-day oat. The adaptability of a variety of oats to a given section is determined largely by the time of its maturity. Further south, where oats are seeded principally in the fall, its adaptability is determined largely by its ability to withstand winter freezing. The tests with wheat at the different experiment stations also show a wide difference in yields of varieties.

While these are only a few of the many varieties that were tested, they show that some varieties yield better than others.

There is possibly greater increase in yields to be secured from seed selection within the same variety. This can be done by selecting the seed from the highest yielding individual plants, and thus we have the "survival of the fittest". As an average of seven years, the Ontario Agricultural College produced 62 bushels of oats per acre from large seed and 47 bushels from small seed; both selected from the same stock each year.

*Illinois Bulletin No. 195.

There are two general methods of seed selection:

(1) Mass selection.
(2) Pedigreed selection.

Mass selection is the method that should be followed generally by the majority of farmers. Mass selection consists in selecting good seed from the best individual plants in the field. Some of the important points to be observed in selecting seed corn are:

(1) Maturity - Select ears from mature plants.

(2) Size and length of shank - Shank should be of medium length and strong enough to bend over in the form of a curve.

(3) Stocky plants. - Plants that are not broken easily by wind.

(4) Position of ears on stalks - Select medium height ears.

(5) Environment - Select ears from a hill containing three plants, stalk that have had competition.

(6) High yielding stalks.

There is great improvement by seed selection within the same variety as shown by the Nebraska Station*:

	Yield, bushels per acre		
	1907	1908	Average
Average of 11 selected strains, corn	82.0	66	74.0
Checks (original stock)	72.5	59	65.7
Difference	9.5	7	8.3

Influence of Pedigree Selection on Composition - Ten Generations of Corn Breeding at Illinois Experiment Station.

Year	High Protein Crop percent	Low Protein Crop percent	High Oil Crop Percent	Low Oil Crop Percent
1896	10.92	10.92	4.70	4.70
1915	14.53	7.26	8.46	2.07

Pedigreed seed selection is more complicated, and should be undertaken

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*Nebraska Bulletin No. 112.

only by experiment stations, and farmers with agricultural training. The above results show a difference of 7.27% between high and low protein, and 6.39% between high and low oil content.

The improvement of small grains by seed selection involves the use of a seed plot, as it would be quite inconvenient to make selections over a large area. The main points to be observed in selecting seed from the small grains are as follows:

(1) Heavy heads
(2) Plants that tiller well
(3) Stiff straw
(4) Plants that resist disease:
    (a) Wheat - scab and rust
    (b) Oats - rust and blight
    (c) Rye - ergot
(5) Early maturing

It is advisable to plant these heads in 1 row tests for thus each head is planted separately, and seed from the highest yielding rows can be used for planting the seed patch the succeeding year. This method is very necessary in improving wheat.

Comparison of Large and Small Wheat Kernels for Seed.

Station	Yields in bushels per acre Large Seed	Yields in bushels per acre Small Seed	Difference in favor of large seed
Indiana Bulletin No. 36	30.5	27.9	2.6 bushels
Ontario Agricultural College, 1905 Report	46.9	40.4	6.5 "
Tennessee Bultins No. 4 and No. 16	28.6	23.4	5.2 "
Averages	30.8	27.0	3.6 "

Comparison of Heavy and Light Weight of Seed

Station	Yield in bushels per acre Heavy Seed	Yield in bushels per acre Light Seed	Increase
Minnesota Bulletin No. 115	24.8	20.4	4.6 bushels
Nevada Bulletin No. 72	27.9	22.8	5.1 "
Kansas B. P. I. No. 78	27.1	25.2	1.9 "
Ontario B. P. I. No. 78	38.6	33.7	4.9 "
Averages	30.7	26.6	4.1 "

The above results at these stations show an increase of 4.1 bushels of grain per acre from planting heavy seed. All bulk planting seed should be thoroughly recleaned, the dirt and light immature grains being blown out.

Treating small grains for disease is highly profitable. Smut in wheat and oats can be treated with a solution of formalin. Add one pint of formalin to 30 gallons of water. The grain can be placed on a tight floor in a thin layer, and the solution sprinkled over. The grain should be stirred thoroughly and covered over with a tarpaulin for six to twelve hours. This treatment costs about 1½¢ per bushel, and may increase the yield five to ten bushels per acre, if the seed are affected with smut. Ergot in rye can be treated by using a 20-percent salt solution. Dump the grain into the solution, taking care not to let the seed remain in the solution long enough to swell.

The proper storage of all planting seed is very essential. The proper place for storing seed is a Seed Room which is constructed to protect the grain from birds, and rats. The Seed Room should be well ventilated, and should be kept at a temperature ranging from 50 to 80 degrees F. Excessive moisture and freezing are harmful.

Results from Different Methods of Storing*. (Corn)

Place	Strong	Weak	Bad
Seed Room	95.0	3.3	1.7
Garret, Kitchen	92.0	7.5	. .
Tool Shed, closed	91.7	6.6	1.7
Furnace Room	79.6	18.4	. .
Cellar, damp	75.0	23.3	1.7

Germination Test of Corn Taken from Planter Boxes (Iowa)

	No. Boxes		Percentage Strong	Percentage Weak	Percentage Bad
Total	397	Average	65	24	11

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*Bowman & Crossley.

The vitality of grain is influenced by maturity, amount of moisture at the time of selection, and the method of storage.

The yields of grain crops in the United States could be increased by millions of bushels by suing the varieties best adapted to the conditions, and seed carefully selected, treated for disease, and stored under proper conditions. Dr. Seaman A. Knapp said*: "It is possible to increase the crop yield in the South 50 percent by the use of seed of higher vitality, pure bred, and carefully selected".

X. CROP SELECTION AND ADAPTATION.

What crops to produce in a community is of great economic importance. Intensive crops should be grown on lands suited to them and leave the lands not well adapted for growing less intensive crops. There is a section in New York well suited to growing apples. To grow wheat on this land would be using it too extensively. On the other hand, some farmers put steep hillsides in cultivated crops when such land should be put in permanent pastures or left to grow timber. This is farming the land too intensively** It would be folly to grow nothing but red top on land well-adapted to growing alfalfa or sweet clover. In the consideration of the relative profitableness of corn and beets, for example, account must be taken of the difference in the acreage of each crop a farmer can handle. It is a well-known fact that a farmer can grow more acres of corn than of beets. It is a mistake to compare profits per acre and stop there but profit per acre must be multiplied by the number of acres the farmer can handle. It is also desirable to have an even and continuous demand for man and horse labor. It is also very important to consider the profitableness of the other enterprises such as dairying, cattle feeding, or hog feeding, which may be based on the corn crop. Some crops can be grown over a wide area. Others are more limited in area because of climatic and soil conditions.

*Progressive Farmer - Feb. 24, 1917.

**Warren - Farm Management. P. 154 - 156.

It happens that, while corn has more extended uses and more exclusive uses than sugar beets, the world has a greater area physically suited to beet culture than to corn culture. It is hardly probable, therefore, that the sugar beet will ever be able to compete with corn on even terms in the corn belt of the United States.

XI. USING BEST LEGUMES.

There is a great possible increase in crop production by the intelligent use of more legumes. Dr. Knapp once said: "It is possible to increase crop production in the South 50 percent by the abundant use of legumes". What legumes are best suited to the different states has been pretty well worked out by the experiment stations and extension workers. The legume used should in most cases be the one that will give the greatest yield, thereby furnishing the most feed for livestock and more nitrogen and organic matter for the soil. For this purpose, alfalfa, sweet clover,and mammoth clover have the greatest efficiency. In the South, the annual legumes such as crimson and bur clover have a great economic value in restoring soil fertility. The seed can be planted in the cotton and corn at the last cultivation thereby requiring very little extra labor. The clover makes a good fall growth, under favorable conditions,furnishes protection against leaching and erosion, and furnishes an abundance of nitrogen and organic matter for the subsequent crops. The average yield of alfalfa in the United States is 2.5 tons while the yield of red clover is 1.3 tons*. Sweet clover is also very promising as a pasture crop and soil improver. At the Illinois Experiment Station**, the total tops and roots of sweet clover contained 12,777 pounds of dry matter and 228 pounds of nitrogen per acre or as much nitrogen and organic matter as is contained in 25 tons of average farm manure.

*Joseph E. Wing - Meadows and Pastures. P. 247.
**Hopkins - Soil Fertility and Permanent Agriculture. P. 220.

XII. IMPROVING PERMANENT PASTURES.

In all types of farming in which livestock occupy a relatively important position, some form of pasture land is very desirable. If a portion of the land is rough or too rolling for cultivation, it is generally used as a permanent pasture. In fact, the permanent pasture is generally the land too poor for cultivated crops. As a general proposition, very little effort is made to maintain the soil fertility of the pasture land and as a consequence after a few years the yield of nutritious grasses is very small and the farmer gets small returns per acre from his land.

On high priced land especially, rotation pastures are more economical but a few acres of permanent pasture are necessary for the best and most economic handling of livestock. To make permanent pasture productive requires the application of mineral fertilizers to make up for the calcium and phosphorus and potassium removed by the animals. But does it really pay to apply manures and mineral fertilizers to permanent pasture? The late Joseph E. Wing of Ohio, an authority on the care and management of pastures, advocates the practice. This is what he said*: "In our lawn which is newly taken in from an old bluegrass pasture, I applied, in the winter of 1908, manure to one square rod of grass, giving it only a fairly liberal dressing of ten tons to the acre. In 1909, I harvested the square rod with a scythe and it yielded 125 pounds while the unmanured rod right alongside made a yield of 40 pounds allowing for moisture of dew. These weights were at the rate of 3½ and 10 tons per acre. Thus the manure made an increase of 6½ tons per acre. This was cut in May; so there was nearly as much more growth during the summer and fall which illustrates just how profitable bluegrass pasture may be. Ten tons of silage corn is considered a fair yield of forage. Is not ten tons of green grass eaten off by good animals as likely to give profits?" Owing to the

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*Joseph E. Wing - Meadows and Pastures. P. 293 - 303.

fact that farm manures are so scarce, it hardly seems practical, as a general proposition, to apply manures to permanent pasture, but there is no doubt that most pastures should have applications of calcium and phosphorus, and sometimes potassium salts should be added, quite often on peat and sandy lands.

It is an excellent practice to feed farm animals on pasture in good weather, taking care to move the feeding troughs from place to place in order that too great an accumulation of manure may not occur at any one place but rather that the manure should be well scattered over the thin places. All pastures should have one or more legumes in the mixture. Thin places should be manured and reseeded and weeds and bushes should be clipped often enough to effect their control. With proper management, permanent pastures could be made much more efficient in producing food for livestock.

As land becomes more valuable, it is no doubt a better practice to rotate most of the pasture land. The tendency now is toward using the pasture in a regular crop rotation. There are some advantages for this system. Rotated pastures usually carry more stock per acre. Also light soils do not hold grass well and do better where rotated. This practice gives all the land a chance for improvement. Another advantage is that the weeds do not become so troublesome. Thin land takes its turn in the regular rotation and is improved by the legumes in the pasture mixture and the manure from the livestock. This system usually permits of the pasture land being plowed in the fall which gives a better distribution of both man and horse labor. The question arises whether or not the rotated pasture should consist of one grass or a mixture. It is undoubtedly true that a mixture will furnish more grazing and likely be better for the land and the livestock. A comparison of one grass with a mixture is given in the following table*:

*Virginia Bulletin No. 193.

Crop	2-yr. Average Yield.
Timothy alone	3857 pounds
Red top alone	3301 "
Timothy and red top	4460 "
Timothy and red clover	5440 "
Orchard grass	1575 "
Orchard grass and red clover . . .	2460 "

From the above results it is apparent that mixtures give better yields than single grasses. It seems advisable to use a mixture made up largely of legumes but containing at least one non-legume. The best mixture will vary for different sections. Where there is sufficient lime in the soil, sweet clover and alfalfa should form part of the mixture. I would suggest the following mixture for the corn belt soils:

Timothy	5 pounds per acre.
Alsike	5 " " "
Alfalfa	5 " " "
Sweet Clover	5 " " "

For the Southern soils, it would be advisable to substitute orchard grass for the timothy. Ground lime rock at the rate of two tons per acre, and ground phosphate rock at the rate of 1000 pounds per acre should be used once in every five years. It is a good practice to apply the calcium and phosphorus just ahead of seeding to the legume mixture for pasture which should occupy two years in the regular rotation.

XIII. POPULATION

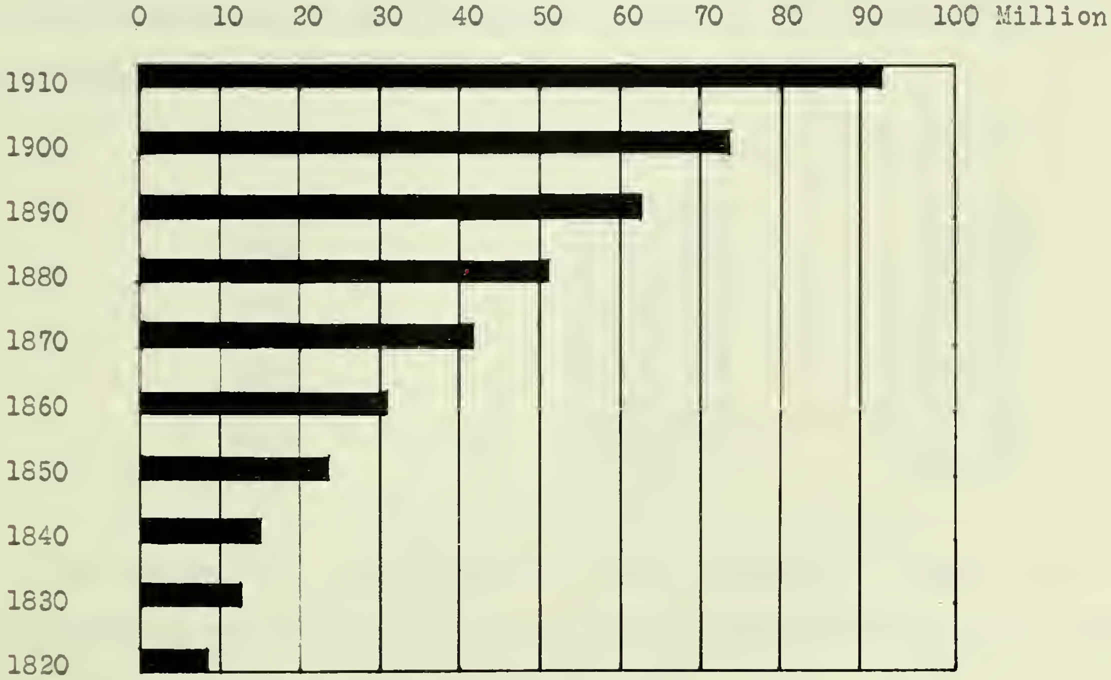
There was a steady increase in population in the United States from 1820 to 1910. The figures in the following table* illustrate the growth in population, land area, population per square mile and the percent of increase:

*Census Report, 1910. Abstract P. 28.

Census	Population	Area Square miles	Population Square miles	Percent Increase.
1910	91,972,226	2,973,890	30.6	21
1900	75,994,575	2,973,159	25.6	20.7
1890	62,847,714	2,973,965	21.2	25.5
1880	50,155,783	2,973,965	16.9	30.1
1870	38,558,371	2,973,965	13.0	22.6
1860	31,443,321	2,973,965	10.6	35.6
1850	23,191,876	2,944,337	7.9	35.9
1840	17,069,453	1,753,588	9.7	32.7
1830	12,866,020	1,753,588	7.3	33.5
1820	9,638,453	1,753,588	5.5	33.1

The rate of increase as shown by the Census was lowest for the period from 1890 to 1900. The greatest increase in population was from 1840 to 1860. The decrease in population per square mile as reported by the Census of 1850 was due to the addition of new thinly populated territory during the preceding decade.

The increase in population by decennial periods from 1820 to 1910 as given by the Census Report, is here shown in graphic form:



XIV. FACTORS INFLUENCING POPULATION INCREASE.

The factors influencing the future population increase in the United

States will, in all probability, be of the same nature of those of the past, differing, however, in relative importance. In the early days of the settlement of this country when the population was small, one of the prime causes of increase in population was immigration from European countries. This original stock has since multiplied very rapidly and in 1910 the number of "native white" population had reached a total of 68,389,105 or 74.4 percent of the population of the United States. As in the past, the sources of the future increase in population will be mainly by natural increase and by immigration.

The increase by birth will be the chief source of increase. Immigration will still be a factor but of relatively decreasing importance. In the early history of our population, immigration had very much greater significance because the population was small and therefore influenced by smaller numbers of immigrants coming to our shores.

A comparison of the immigration and population by decades, will show a greater rate of increase of the former over the latter with the exception of the Census* of 1910.

Decade	Population	Immigration
1830	12,866,020	143,439
1840	17,069,453	599,125
1850	23,191,876	1,713,251
1860	31,443,321	2,598,214
1870	38,558,371	2,318,824
1880	50,155,783	2,812,191
1890	62,947,714	5,246,616
1900	75,994,575	3,844,420
1910	91,972,266	8,796,308

The number of arrivals reported in 1907 exceeds the largest number for one year (1906) by 184,614; the year 1907 having been the banner year of immigration to the United States.

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*The Americana - Volume X.

XV. RELATIVE CONGESTION OF POPULATION.

Although the United States ranks first in land area among the countries of North and South America, it also has the greatest density of population per square mile, as shown by the following table:

North America	14.31
United States	30.9
Canada	1.9
Mexico	17.5
South America	6.7
Argentina	6.2
Brazil	5.3
Chile	12.0
Uruguay	16.3

The United States is more densely populated than the other countries yet there are other advantages in the United States that will in part overcome the seemingly disadvantage. Transportation facilities and market conditions are very much more favorable for the economic production of livestock in the United States than in the other countries of North or South America. In most of these countries, however, the Governments encourage, to a small degree, the development of their agricultural resources and this attitude of the government will likely become more favorable toward agriculture in the future. The main factor that will attract immigration to these countries is the fact that large areas of land are either available for entry by homesteaders or for sale at low prices.

XVI. CANADA

Canada is the most sparsely settled of any of the countries of America. With a land area of 3,603,910 square miles or a slightly greater land area than the United States, Canada had, in 1910, only 7,206,643 inhabitants. Much of this vast territory is covered with lakes and mountains which reduces to a considerable extent the land area suitable for profitable agriculture. Canada offers some attraction to immigration. The climate is suited to small grain farming and to the

production of livestock. The greatest handicap to livestock farming is long winters which make it necessary to provide warm barns. Then the short grazing season makes it more expensive to carry livestock through the winter. Though a dependency of Great Britian, Canada enjoys a very stable and democratic form of government.

XVII. MEXICO

Mexico offers more inducements for livestock farming than Canada. Among the advantages are cheap lands, mild winters, and long growing seasons which permit of livestock being raised largely on pasture and with relatively small amounts of grain. Among the disadvantages, scarcity of water and the fever tick are the most serious, however, the latter will be ultimately exterminated, as is now being done throughout the South. The system of government in Mexico is very unfavorable to agriculture and especially for livestock farming. With better political conditions, Mexico will develop into relatively a much better livestock country.

XVIII.ARGENTINA

The Argentine Republic* is naturally a livestock country. It is favored with an ideal climate for stock raising, and in 1910, Argentina exported $25,480,000 worth of beef while the United States exported only $12,196,000 worth. Since that time the exports have increased in Argentina and greatly decreased in the United States.

The form of government is very similar to that of the United States. The executive power is vested in a President elected for a term of six years. The legislative power is vested in a Senate of 30 members and a house of 120 deputies elected for four years by the people.

XIX. BRAZIL

Brazil has a land area of 3,218,991 square miles, or slightly greater

*Illinois Circular 164.

than the United States, and only 23,070,969 population. The climate is mild and the soil is well adapted to agriculture. It is suited especially for the production of beef and mutton. There are other smaller countries of South America such as Chile, Uruguay, Bolivia, Paraguay, Venezuela, and others in which the climate and soils are suited to agriculture. Brazil, also these other named States, has a republican form of government which is in many respects very similar to that of the United States. South America lies principally in the Torrid and north half of the South Temperate zone. The winters, therefore, are short and mild thereby requiring small expense in barn equipment for housing livestock. This together with cheap labor and lands, and a long growing season makes South America one of the most favored livestock sections of the world. At the present, transportation facilities, poor local markets, and the presence of the fever tick and the foot-and-mouth disease work against economical crop and livestock production, however, these handicaps will be ultimately overcome, and when this happens, there seems to be no doubt but that South America will rank among the biggest producers of livestock products, and for the next fifty years, very likely, will rival the United States in attracting immigration.

XX. PROPORTION OF OUR POPULATION ENGAGED IN AGRICULTURE AND OTHER FORMS OF PRODUCTION.

The proportion of the population living in the urban and rural territory of continental United States, according to the last four Census Reports, is given in the following table*:

Class	1880	1890	1900	1910
Urban	14,772,438	22,720,223	30,797,185	42,623,383
Rural	35,383,345	40,227,491	45,197,390	45,348,883
Totals	50,155,783	62,947,714	75,994,575	87,972,266

*Census Report - Vol. IV P. 40.

Percent of Distribution

Class	1880	1890	1900	1910
Urban	29.5	36.1	40.5	46.3
Rural	70.5	63.9	59.5	53.7

These figures show a tendency, which began as early as 1820, toward a concentration of the population in the cities at the expense of the rural sections. In 1880, only 29.5 percent of the population lived in cities and 70 percent lived in rural sections while in 1910 only 53.7 percent of the population lived in the country and 46.3 percent lived in cities. The following table will show the proportion of population engaged in the various classes of occupations.

The Number and Proportion of Persons in the General

Divisions of Occupations - 1910.*

	Number	Distribution
All occupations	38,167,336	100.0 percent
Agriculture, Forestry, Animal Husbandry	12,659,203	33.2 "
Extraction of minerals	964,824	2.5 "
Manufacturing and mechanical industries	10,658,881	27.9 "
Transportation	2,637,671	6.9 "
Trade	3,614,670	9.5 "
Public service	459,291	1.2 "
Professional service	1,663,569	4.4 "
Domestic and personal	3,772,174	9.9 "
Clerical occupations	1,737,053	4.6 "

These figures offer one explanation for the concentration of people in cities. It is significant that only 33.2 percent of those with occupations were engaged in agriculture while 66.8 percent were engaged in other occupations carried on largely in cities.

XXI. CONSUMPTION OF FARM PRODUCTS IN THE UNITED STATES.

The proportion of different crops used for direct human consumption

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*Thirteenth Census - Vol. IV P. 40

varies greatly. Wheat is used largely for human consumption, and corn and oats supply the bulk of the grain feed for livestock. The proportion of the improved area required to grow crops used for direct human consumption and to supply feed for animals is given in the following table:

Crops	1909	1899	1889	1879
All cereals	40.0	44.6	39.3	41.7
Corn	20.6	22.9	20.2	21.7
Oats	7.3	7.1	7.9	5.7
Wheat	9.3	12.7	9.4	12.4
Other cereals	2.8	1.9	1.8	1.7
Hay and forage	15.1	19.9	14.8	10.8
Vegetables	1.5	1.4	2.3	2.0
Potatoes, sweet potatoes	0.9	0.8	0.9	- -
Peanuts	0.2	0.1	0.3	0.2
Flaxseed	0.4	0.5	0.4	- -

The proportion of the improved farm area required to grow crops used for direct human consumption is relatively small as shown by the following table:

Wheat	8.6
Corn	3.4
Oats	0.9
Barley	0.7
Rice	0.1
Potatoes and sweet potatoes . . .	0.9
Vegetable	1.4
Large fruits	2.3
Small fruits	0.1
Peanuts	0.2

The estimated disposition of feed crops on the farms of the United States is given in the following table*:

	Corn Percent	Oats Percent	Barley Percent	Hay Percent
Horses and mules	27.0	46.4	14.8	35.9
Swine	26.8	1.8	9.4	0.3
Milch cows	8.6	5.0	4.4	23.2
Other cattle . . .	9.4	1.8	1.1	15.5
Sheep	2.2	1.8	0.6	5.1
Poultry	3.6	2.2	2.2	- -

*Farmers Bulletin 629 - P. 8 - 9.

Human beings . . .	3.4	0.9	0.7	- -
Seed	0.8	7.6	7.1	- -
Other and doubtful	3.8	4.5	6.7	3.0
Total on farms . .	85.6	72.0	47.0	83.0
Not used on farms	14.4	28.0	53.0	17.0

It is apparent from the above table that approximately 80 percent of the corn and hay, 65 percent of the oats, and 40 percent of the barley is fed to animals on the farm. Thus a small percent of these crops, except barley, is marketed direct. Not all the crops fed to animals was marketed through them, however, as a considerable portion was fed to work animals and breeding animals kept on the farm.

XXII. PROPORTION OF CROPS NOT DIRECTLY EDIBLE: DAMAGED CEREALS, MILL FEED, AND STRAW.

In the production of many crops, there is one or more by-products, and other by-products are obtained in the preparation and manufacture of these crops into products suitable for human consumption. Some of these by-products which are not directly edible are given in the following table*:

	Amount fed in tons	Percent fed
Wheat straw	28,586,000	44.8
Oat straw	30,029,000	71.8
Barley straw	4,459,000	60.0
Rye straw	791,000	24.1
Rice straw	843,000	59.9
All straw	117,754,000	54.9
Corn stover	245,253,000	81.5

The paper manufacturing industries used 303,137 tons of straw in 1909 in making paper. A large percent of the straws go to waste. In the wheat growing states millions of tons of straw are burned annually.

The total grain ground in 1909 by mills manufacturing chiefly feed for livestock was 70,234,080 bushels. The yield of all cereals in 1909 was estimated

*Meat Situation in the United States. Part IV. P. 11.

at 4,500,000,000 bushels; so the proportion of grain ground for mill feed was approximately 0.6 percent. Of the wheat made into flour about five percent* is low grade or "red dog" flour and suitable only for cattle feed.

The Proportion of the Improved Area not Producing Edible Food.

Hay and forage	15.1
Non-edible legumes	0.3

The total acreage in hay and forage in 1909 was 72,280,776 acres. The acreage in clover - 2,445,263, and the amount in alfalfa was 4,707,146 acres making a total of 7,150,449 acres in legumes.

PROPORTION OF FARM AREA NOT PRODUCING HARVESTED CROPS.

The climate, soils, and rainfall in the United States are well suited to the grasses and clovers, Many pasture grasses and clovers are found growing luxuriantly in most sections of the United States, and a considerable portion of the improved farm area is devoted to pastures. The following table shows the relative acreage in crops and pastures:

	Acres.
Improved farm land in 1910	478,451,750
Acreage in crops	311,293,382
Acreage in pasture	167,158,378

It is significant that 167,158,378 acres of the improved land was in pasture. There was also 400,346,675 acres of unimproved farm land which was used largely for pasture. Much of this vast area was doubtless rough and covered with some timber and therefore furnished very little pasture,however, it had some economic value in producing livestock. There was therefore, in pasture in 1910, a total of 567,505,053 acres or approximately 58 percent of the Farm area.

*Leach - Food Inspection and Analysis. P. 311.

XXIII. VALUE OF AREA NOT NOW IN FARMS FOR PRODUCING CROPS AND ANIMALS.

There are 540,000,000 acres of unimproved lands that will be ultimately added to the improved farm area, and 200,000,000 acres of this will come from the present unimproved farm area. It seems possible that this will ultimately compare very favorably in economic production of crops with our present average lands.

The 100,000,000 acres of swamp land, to be added by drainage, and the 40,000,000 acres of irrigated land will compare very favorably with the present corn belt soils.

The 200,000,000 acres of semi-arid land to be added to the present improved farm area will have less economic value for producing crops and animals than our average present crop area. Thus it seems possible that at some time in the future, when all these unimproved lands, amounting to 540,000,000 acres, are brought under cultivation, that our present improved farm area, 478,451,750 acres, will be practically doubled. It seems barely possible, however, that this additional improved farm area will ever have as great economic value for the production of crops and animals as our present improved farm area.

XXIV. EFFICIENCY OF LAND FOR PRODUCING FOOD FOR PEOPLE.

The efficiency of land for producing food for people varies greatly. The tillable portion is capable of directly producing food for human consumption while other portions have little economic value except in producing crops which must be converted into edible form by animals. Then, again, land will produce more food when planted to certain crops than others. The relative efficiency of land in different crops for producing food for people is given in the following table*:

*U. S. Experiment Station Bulletin No. 28.

	Food value per pound calories	Pounds per acre	Calories per acre	Ratio to wheat
Entire wheat flour	1,660	1,800	2,988,000	100 percent
Native beef as purchased	1,130	200	226,000	7 "
Mutton as purchased	1,270	250	318,750	11 "
Corn meal (unbolted)	1,550	3,600	5,580,000	186 "
Whole milk	325	4,000	1,300,000	43 "
Oatmeal	1,860	1,800	3,348,000	112 "
Rice	1,630	2,400	3,912,000	131 "
Rye meal or flour	1,630	1,800	2,934,000	98 "
Beans	1,590	2,400	3,816,000	129 "
Potatoes	325	24,000	7,800,000	260 "
Sweet potatoes	480	30,000	14,400,000	482 "

The above figures are based on a yield of 30 bushels of wheat and 65 bushels of corn per acre which is possible only on the best lands. It is significant that an acre of wheat is approximately 14 times as efficient for producing food for human consumption as an acre producing beef while an acre in sweet potatoes will produce as many calories as 69 acres producing beef. Thus in the early history of the development of the United States, wheat pushed the ranges farther westward. Then in turn, corn, being more efficient than wheat, pushed the wheat belt further westward. Those crops, therefore, which are the least productive must gradually give way to the crops that are more efficient as the land advances in price and the foods become relatively scarce. Livestock have a greater economic value in producing food for people than would seem from the figures given above in that animal products - beef, mutton, pork, and milk - can be produced on roughages, damaged grains, and by-products that cannot be used for human consumption. Also these animal products can be produced on unimproved lands that have little or no economic value in producing harvested crops. Another factor that will have its influence is our desire for meat and milk. The people of this country will no doubt continue to eat meat and butter and drink milk as long as they have money to buy it. It is not very likely that the consumption of meat

and milk will decrease in the United States, nor is it desirable that such should be the case, but rather the consumption will increase with increase in population until food becomes relatively very much scarcer than has been the case in the past.

It is impossible to keep up soil fertility without the use of legumes*. In the corn belt a rotation that is used is: Corn 2 years, followed by clover and timothy. Another rotation used in grain sections is: Corn, small grain, and legumes, making a three-year rotation. In potato sections**, a three-year rotation of potatoes, small grain, and clover. It would be impossible to grow a high yielding crop - corn, potatoes, etc. - on land every year and maintain the fertility of the soil. The best we can do is to grow a high yielding crop on one-third of the land, medium yielding crops - small grains - on one-third, and legumes on the other third, thus using a three-year rotation.

Land is more efficient in producing food for direct human consumption than through animal products from edible crops. It requires approximately seven pounds of corn, when balanced with clover hay, to produce a pound of beef***, and the same amount of corn, if fed to a good dairy cow, would produce 24 pounds of milk. Thus seven pounds of corn converted into beef would have a food value of 1130 calories and when converted into milk would have a food value of 7,800 calories, or, stated differently, the dairy cow is approximately seven times as efficient in converting feed into food for human beings as is the beef animal. Therefore, as a country becomes more densely populated, the tendency is to change from a beef producing to a dairy section.

XXV. A COMBINATION OF EDIBLE CROPS AND ANIMAL PRODUCTS.

A combination of edible crops and animal products is the most economical system of food production. Under any system of farming, there will be some crops

*Carver - Principles of Rural Economics. P. 239

**Warren - Farm Management. P. 406 - 415.

***Illinois Bulletin No. 103

and by-products - hay, straws, and other roughages - that will go to waste largely unless sufficient livestock are kept to consume this waste. The use of forage crops is more economical from a labor standpoint but less efficient for producing food considered from the standpoint of the land. Green forage crops are more efficient than dry forage crops. In curing forage, the most nutritious and palatable parts are largely wasted. Also dew, rains, and fermentation affect the digestibility and render them less* valuable. Where land is abundant and cheap, the liberal use of forage crops, such as sweet clover, alfalfa, soybeans, velvet beans, and other crops that livestock can use without the expense of having to be harvested, will prove highly profitable. Livestock on the above forage crops should be fed a small amount of grain which furnishes the necessary carbohydrate and fat material to balance the rich protein forage crops. The above system is especially satisfactory in that a relatively small amount of labor is required and the fertility of the soil is in large measure maintained.

By the use of by-products, such as dried beet pulp, wheat bran and shorts dried brewers grains, malt sprouts, cotton seed meal and cake, linseed oil meal, blood meal, tankage, and other by-products, in the feeding of animals, there is quite an effective saving of materials that would otherwise be largely lost. Most of these by-products are rich protein feeds and make especially efficient supplements* for the grains. That these by-products have a high value in feeding animals is shown from the following table**:

Average Ration	Digestible nutrients eaten daily Pounds	Daily yield of milk solids Pounds	Dig. nutrient eaten for one pound milk solids Pounds
Ration I			
Ground Oats 5#, timothy hay 5#, Ground peas 6#, Corn silage 40#	15.3	2.7	5.6

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*Henry and Morrison - Feeds and Feeding. P. 50.
**Henry and Morrison - Feeds and Feeding. P. 369.

Ration II			
Malt sprouts, 2#, Timothy hay 15#, Dried brewers grains 3#, Gluten feed 3#, Corn silage 25#	14.1	2.7	5.2

The table shows that the ration containing malt sprouts, dried brewers grains, and gluten feed was slightly more efficient for milk production than one of oats and peas, containing slightly more digestible matter.

There is not much saving from using mill feeds and other ground grains except in feeding very young stock or under certain other conditions as the expense in grinding and preparing the feeds is, in most cases, equal to, if not greater than the saving effected.

Damaged grains, those but slightly damaged which would,because of off color or other defect, render them unmarketable, are not suitable for human consumption but make very satisfactory feeds for livestock, however, it must not be inferred from these remarks that seriously damaged grains have any great value in feeding livestock. In fact it is possible to seriously injure the health of animals by feeding badly damaged grains or other products.

Pastures are absolutely essential for the economical maintenance of livestock. This is especially true where land is cheap. The aftermath of pastures and meadows should in most cases be left on the land for protection to the young plants and to furnish organic matter.

The range area has been an important factor in the production of beef and mutton in the United States especially since 1850. It has had very little economic value in the production of pork and milk however. A large part of the present range area is not suited to the economic production of cultivated crops but this area will have a value in producing feeder animals to be finished for the market principally in the corn belt states.

XXVI. LABOR

The proper adjustment of labor involves one of the most difficult problems in farm management, and to make the most effective use of labor requires a careful study of the farm operations. Farm labor may be subdivided into two kinds: man labor, and horse labor. Farm labor constitutes practically 50 percent of the operating expenses in the production of crops.

No matter how profitable a product is, there is a limit to the amount that can be produced with a given amount of labor. It is very important to provide a full years work for both men and horses, and the farmers' problem is to select a combination of profitable crops that will best distribute both man and horse labor throughout the year. Corn conflicts more or less with cotton, wheat, alfalfa, and tobacco. Cotton interferes with most other crops. None of the meat producing animals requires much work. Beef cattle interfere very little with farm work. During the spring and summer they are on pasture, and, if the water supply is good they require very little attention. They require some attention during winter but at this time there is very little other farm work that can be done. Sheep interfere very little with general farm work except at lambing time and at shearing time which latter can usually be done on rainy days when little or no other farm work could be done.

Hogs require little attention except when the pigs are coming. If the water and feed supply are conveniently arranged, there is little serious conflict with other farm work. Sometimes hogs are used to "hog off" crops and may then be a help in getting farm work done.

Dairying is the standard illustration of an ideal type of farming because it provides winter work. This is true only when dairying is combined with other work. In Minnesota* it was found that on dairy farms the average work day was 8.6

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*Minnesota Bulletins 124 - 125.

hours while on grain farms it was 7.4 hours. It was also shown that the demand for horse labor varied from 600 to 1500 hours per year depending largely upon the type of farming. The average cost for the keep of a horse for twelve months was practically 25 cents per day or $91.00 per year, and the horse worked about three hours per day at a cost of 8 - 9¢ per hour.

Some of the factors in the efficient use of labor are*:

(1) Relatively large crop acreage per man.
(2) Large productive work units per man.
(3) Large crop acreage per horse.
(4) Large productive work units per horse.

A system of farming which would distribute the horse and man labor thru out the year would tend to reduce the number of men and horses required to perform the farm work and thereby reduce the expenses of crop production. Neither specialized farming nor grain farming will give a good distribution of labor and thus to effect the most efficient use of farm labor it requires a combination of general crop production and livestock farming. Just what the crops produced should be and the phase of livestock farming done will depend upon several factors, namely: climate, soil type, capital, transportation, and marketing facilities, relative prices of crops and animal products, and general knowledge of agriculture.

XXVII. CAPITAL

For the most efficient use of capital, there must be the proper balance between land, labor, and equipment, and the necessary cash capital. Some types of farming require larger capital than others and some require the capital to be invested for longer periods. Farmers with small capital get most of their profits from crops. Upon an investigation of 578 farms in Livingston County, New York, it was found that farms with $5,000.00 and less, 73 percent of the receipts was from animal products. Not until the capital invested reached approximately $17,000.00 did the receipts from animals and their products equal those from crops.

*Warren - Farm Management. Pp. 109, 209, 330, 340, 561.

The amount invested in machinery and buildings per acre for different sized farms is shown in the following table:

Acres farmed	Value of Machinery	Investment in Machinery per acre.
3	$53.00	$31.18
50 - 99	106.00	2.16
260 - 499	263.00	1.38
500 - 999	377.00	1.31

The above table shows that too much capital is invested per acre on small farms. It is significant that the amount invested in machinery per acre on the small farm of 50 - 100 acres was $2.16 while on farms from 260 - 500 acres there was only $1.38 invested per acre in farm machinery.

The proper districution of capital on the farm is of very great importance. The average capital and its distribution on farms in the United States is given in the following table*:

	1900		1910	
Land exclusive of buildings	$2,285	64%	$4,476.	70%
Buildings	620	17	995	15
Implements and machinery	133	4	199	3
Livestock	536	15	774	12
Total	3,574	100%	6,444	100%

The figures on 615 farms in New York operated by owners show the relation of capital to profits**:

Capital	Number of farms	Average labor income
$2,000 or less	36	$192
2,001 - 4,000	200	240
4,001 - 6,000	183	399
6,001 - 8,000	94	530
8,001 - 10,000	45	630
10,001 - 15,000	44	870
Over 15,000	13	1,164

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*Warren - Farm Management. P. 295.

**Warren - Farm Management. P. 292.

The table shows that the farm with small capital made a correspondingly small income and as the capital increased, the labor income increased proportionally.

Some of the factors in the efficient use of capital are*:

(1) Large percent of the farm in crops.
(2) Small percent of capital in houses and barns.
(3) Small percent of capital in machinery.

There should be as little waste land on the farm as is practical. All land on the farm that has any economic value in producing crops or animals should be used.

The type of farming followed will have some influence on the amount of capital invested in buildings than grain or other forms of livestock farming. The buildings should be ample for housing the animals comfortably but costly barns and equipment are not recommended.

But a small percent of the capital should be invested in farm machinery. The machinery should be well selected with due consideration to the economic value on the particular farm. Farm tractors, threshing out-fits, and other expensive implements can, in many cases be purchased co-operatively by the farmers and thus effect a considerable saving.

XXVIII. MANAGEMENT.

The actual working out of the problems of the economizing of land, labor, and capital is the task of the farm manager. Upon the Farm Manager rests the responsibility of making agriculture respond to favorable conditions. Good management means the proper balance between the different forms of capital, a system of crop rotation which will maintain the fertility of the soil, a simple but effective accounting system which enables the farmer to arrive at the sources of profits and losses, the proper adjustment of labor, breeding and management of live-

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*Warren - Farm Management. P. 561.

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stock, the purchasing of farm supplies, and the marketing of the crops and animals.

Whether he be a manager, renter, landowner, or capitalist, the farm manager must perform the following functions:

(1) Decide how much shall be invested in land, buildings, machinery, horse power, and livestock.

(2) Decide what combination of crops and animals are best suited to his conditions.

(3) That of pushing the work along. That is, seeing that the work is done in the most economic way and at the proper time.

(4) That of buying and selling. He must buy the necessary equipment, seed, fertilizers, livestock, machinery, and other farm supplies.

Marketing the farm crops and animals is a very important part of the successful operation of a farm. It is especially important in the marketing of specialized crops and pedigreed livestock. There can be no efficient use of land, labor, and capital without efficient management.

XXIX. FUTURE SYSTEMS OF LIVESTOCK FARMING IN THE UNITED STATES.

The great cattle ranges of the West havè gradually given way to cultivated crops. The large cattle ranches, comprising some times one hundred thousand acres or more, have been cut up into smaller farms which are being used for the production of grain and livestock, the lands adapted to cultivation being used for the production of wheat and other small grains, and the rougher lands for grazing livestock - mainly cattle and sheep. The range system of livestock farming is becoming a thing of the past, excepting on the semi-arid and arid lands not adapted to growing cultivated crops, and the future systems of livestock farming in the United States will be a combination of crop production and animal production which we may call diversified livestock farming. We must understand the economic principles underlying systems of livestock farming. The proper method to pursue in planning a system of livestock farming is to assume rather fixed conditions in a

certain locality. Then plan a system to suit this locality. Provision must be made for permanent soil fertility:

(1) Maintenance of minerals.
(2) Maintenance of nitrogen.
(3) Maintenance of organic matter.

The principal mineral elements are phosphorus, potassium, and calcium. In cornbelt soils, potassium is seldom needed, except under some conditions as a stimulant, but phosphorus and calcium are nearly always needed on these soils. Phosphorus should be added through the application of ground phosphate rock, and calcium through the application of ground lime rock. It is advisable to add both together ahead of the legume crop in the regular crop rotation. Nitrogen should be added through legume crops, and organic matter should be added by turning under green crops, preferably legume crops, and by the applications of manure and crop residues.

It is more diffcult to maintain the fertility balance on grain farms than under a system of livestock farming. A system of livestock farming should be organized that will maintain the fertility of the soil. A good system for the corn belt is corn, corn, oats, wheat, and clover. This is also a good crop rotation for grain farming in the corn belt. That the fertility of the soil is more easily maintained under a system of livestock farming than under a system of grain farming is shown by a comparison of the fertility balance under both systems.

XXX. FERTILITY BALANCE FOR A 320-ACRE GRAIN FARM.

Typical brown silt loam soil, 5 acres occupied by residence, horse and cattle barns, chicken and hog houses, garden, and out houses; 15 acres devoted to permanent blue grass and white clover pasture, thus leaving 300 acres for crops. The rotation is corn, corn, oats, wheat, and clover. The clover is a mixture of sweet clover and alfalfa, and is sown with oats and wheat.

Crops Produced.

120 acres corn	@ 60 bushels per acre . . .	7,200 bu. corn
60 acres oats	@ 50 bushels per acre . . .	3,000 bu. oats
60 acres wheat	@ 30 bushels per acre . . .	1,800 bu. wheat
60 acres clover	@ 4 tons per acre	240 tons clover

Feeds Consumed by Livestock.

Kind of Animals	Corn Pounds	Oats Pounds	Hay Pounds	Oat Straw Pounds
8 Farm horses	19,936	19,936	28,800	14,400
5 Cows and calves . . .	7,200	7,200	18,000	9,000
2 Sows and pigs	33,120	- - -	- - -	- - -
Totals	60,256	27,136	46,800	23,400
Equivalent in bushels and tons.	1,073 bu.	848 bu.	23 tons	12 tons

Plant Food Removed in Crops Sold and Fed.

Kind of Feed	Nitrogen Pounds	Phosphorus Pounds	Potassium Pounds
6,126 bushels corn sold	6,126	1,041	1,163
2,152 bushels oats sold	1,419	236	244
1,800 bushels wheat sold	2,556	432	468
217 tons clover hay sold . . .	none	1,085	5,228
1,074 bushels corn fed on farm .	376	45	51
848 bushels oats fed on farm .	196	23	34
23 tons clover hay fed	none	31	138
12 tons oat straw fed	50	6	63
Total plant food removed .	10,725	2,899	7,489

Plant Food Returned to the Land.

	N	P	K
23 tons clover hay fed	598	- - -	- - -
30 tons clover, growth on clover after cutting (not removed)	1,200	- - -	- - -
240 tons clover, growth of clover on oat and wheat land (clipped but not removed)	9,600	- - -	- - -
Total plant food returned . . .	11,398 N	- - -	- - -

	N	P	K
Gain or loss in plant food per year	673# gain	2,899# loss	7,499# loss
Gain or loss per acre per year . . .	$2\frac{1}{4}$# gain	10# loss	25# loss
Loss from leaching,per acre	40#	5	5
Total loss per acre per year	37 3/4# N	15# P	30# K

The loss in nitrogen could be partly made up by seeding a winter legume in the corn land. Sweet clover or mammoth clover would suit well for this purpose. The phosphorus loss could be made up by applying 1,000 pounds ground phosphate rock per acre every five years.

The average brown silt loam soils of Illinois contain 227,700 pounds of potassium per acre for the first 40 inches. This would be sufficient to last over seven thousand years.

XXXI. FERTILITY BALANCE FOR A 320-ACRE STOCK FARM.

Assume the conditions the same as for the grain farm. The crops and yields are as follows:

300 acres in crops and rotation pasture.
100 acres in corn to be husked.
20 acres corn for silage
60 acres oats and clover mixture.
60 acres wheat and clover mixture.
60 acres clover mixture for pasture.

Crops Produced.

100 acres corn @ 60 bushels per acre	6,000 bu. corn
20 acres corn @ 12 tons per acre	240 tons silage
60 acres oats @ 50 bushels per acre	3,000 bu. oats
60 acres wheat @ 30 bushels per acre	1,800 bu. wheat
Oat and wheat straw	140 tons
Clover hay (sweet clover and alfalfa)	86 tons
60 acres clover (seeded with oats) grazed	80 tons
60 acres clover (clover pasture) grazed	120 tons

Number of Farm Animals and Rations for each Class.

8 farm horses, ave. weight 1400#. Ration - 7# corn, 7# oats
8# clover hay, 5# oat straw.

40 cows. Winter Ration -(30 pounds silage
(3 pounds corn, 6 pounds oat straw
(1 pound Cottonseed meal

Feeding period - November 1 to May 1.

35 yearlings. Ave. weight 700# each. Winter Ration - (25 pounds silage
(5 pounds Oat straw

Feeding period - November 1 to May 1.

35 yearlings. Ave. weight 700# each. Ration on pasture. 10 pounds corn.

Feeding period - May 1 to October 1.

100 steers. Ave. weight 1000# each. Ration - (16 pounds corn
(8 pounds clover hay
(5 pounds oat straw
(10 pounds silage first 90 days.

50 shotes, ave. weight 200 pounds to follow cattle.

Feeding period - 180 days.

Plant Food Removed in Crops Fed on the Farm.

	Nitrogen Pounds	Phosphorus Pounds	Potassium Pounds
5,956 bushels corn fed on the farm	1,985	253	282
2,920 bushels oats fed on the farm	633	80	117
86 tons clover hay fed on the farm	none	108	648
90 tons straw	360	45	472
225 tons corn silage	498	66	482
200 tons green clover grazed . . .	none	200	1,200
1,600 bushels wheat sold	2,272	384	416
Total plant food removed . . .	5,748	1,116	3,617

Plant Food Returned to the Soil.

3.6 tons Cottonseed meal	319# N	72# P	105# K
200 tons clover grazed (80% returned)	6400	--	- -
86 tons clover hay (65% returned)	2300	--	- -
Total plant food returned	9025	72	105
Loss or gain per year per acre	11# N gain	4# loss	12# loss
Loss from leaching per year per acre	40	5	5
Loss per acre per year	29# N	9# P	17# K

The loss of nitrogen, in all probability, would be less than estimated above owing to the fact that practically all the land is growing a winter legume. It is practical to seed sweet or mammoth clover at the last cultivation of the corn, and this clover together with the late fall and early spring growth on the pasture land turned under for corn would at least balance the loss through leaching.

To replace the phosphorus lost through leaching and removed by crops (9 pounds annually per acre), it would be necessary to apply 500 pounds to 600 pounds of ground phosphate rock per acre every five years. It would be very necessary to apply about two tons of ground lime rock per acre along with the phosphate rock in order that the calcium supply may be maintained. An abundant supply of both phosphorus and calcium in the soil is especially desirable in livestock farming as these two mineral elements are needed in liberal supply in the feed to form large bone of good quality. The amount of potassium removed in a good system of livestock farming is so small compared with the total amount of potassium in the soil that it would not be necessary to make any provision for replacing that element for several hundred years at least.

It is more difficult to determine the relative supply of organic matter. While there is only approximately 700 pounds of organic matter returned in the manure from a ton of dry matter consumed by livestock, actual experience on the farm indicates that the organic matter will be at least maintained, in most cases actually increased for a few years, under a system of diversified livestock farming.

XXXII. ORGANIZING SYSTEMS OF LIVESTOCK FARMING FOR THE MOST EFFICIENT RESULTS.

It must be assumed that the farmer has the necessary land and capital to carry on the business. There are advantages in having enough livestock so that

the marketing can be done in car lots. The amount of land best suited to livestock production will be relatively large. In orgainzing systems of livestock farming, the following points should have due consideration:

(1) Size and location of the farm.
(2) The labor supply.
(3) The proportion of livestock - horses, cattle, sheep, swine, and poultry - to carry.
(4) The arrangement of the buildings - barns, hog houses, etc.
(5) The crop rotation.
(6) A good system for saving and applying manure.

The size and location of the farm is very important. It is very desirable to have the farm located near some shipping point on a good line of railroad, and it is especially desirable for the farm to be located on a gravel or macadam road so that hauling to the shipping point can be done at any season of the year. The size* of the farm best adapted to livestock farming is from 300 to 600 acres.

The arrangement of the buildings is very important. By the proper arrangement of buildings with reference to each other and to the fields, much labor can be saved in the way of caring for the stock, housing the crops, hauling manures, and in getting to and from the fields. To accomplish the above results requires good management which is usually the difference between profit and loss.

XXXIII. SYSTEMS OF LIVESTOCK FARMING FOR THE EAST.

The Department of Farm Management of the New York State College of Agriculture** secured records on 2,743 farms principally in Tompkins, Livingston, and Jefferson counties. The farms that made a labor income as high as $2,500 sold from one to six major products, amounting to over $500 each, and from one to nine minor products. They averaged over three major and four minor products. On some of these farms, milk was the only product amounting to over $500. One farm had no $500 sales except from eggs and poultry. Some of these farms derived their main profits from milk combined with pure-bred livestock. The significant fact

*Warren - Farm Management. Pp. 247 and 264.

discovered by this investigation was that "only those with diversified farms often make a labor income of $2,500". The types of diversified livestock farming in the East will vary somewhat. The most successful type of farming in New York is dairying, combined with potatoes and hay or other cash crops, and with beef cattle, hogs, sheep, and poultry as minor products.

XXXIV. SYSTEMS OF LIVESTOCK FARMING FOR THE CORNBELT.

In the cornbelt, the most generally successful type of farming is the raising of corn, oats, wheat, and alfalfa together with dairying, colts, cattle, sheep, swine, and poultry. The cornbelt will undoubtedly remain a great section for finishing beef cattle, sheep, and hogs. So long as meat products remain relatively high, corn, oats, and alfalfa should be marketed through livestock. In fact, practically all crops raised, except wheat, should be fed on the farm, the manure carefully saved and applied together with ground phosphate and lime rock to the soil. This practice will maintain permanent soil fertility, and should prove more profitable.

This method is followed by a large number of the farmers in the west central counties of Illinois. The Department of Animal Husbandry of the University of Illinois has kept farm records on a number of these farms since 1913. A summary of the results on one of these farms is given below:

Farm No. 1. 329.63 Acres.

Field No.	Acres	Year	Crop	Amount
1	40.5	1916	Corn	53 bushels
2	40.9	1916	Timothy	1.135 tons
3	40.8	1916	Oats	26.9 bushels
4	17.8	1916	Pasture	
5	8.16	1916	Pasture	
6	39.8	1916	Corn	49.9 bushels
7	42.9	1916	Pasture	
8a	16.1	1916	Corn	50 bushels
8b	26.2	1916	Pasture	
9	37.0	1916	Wheat	10.27 bushels

XXXV. DISTRIBUTION OF FARM INVESTMENT.

	1913	1914	1915	1916	1917
Land only, 329.6 acres	$52,315	$52,523	$53,086	$53,086	$53,140
Total land and buildings	62,499	63,003	64,515	65,222	65,896
Machinery and equipment	1,878	1,963	2,044	1,898	1,953
Total livestock	7,135	10,171	6,556	5,870	5,944
Total investment	74,080	76,783	75,814	75,441	76,508
Total crop receipts	441	457	596	511	Not reported
Total livestock receipts	5,100	8,473	6,385	7,954	Not reported
Total cash receipts	5,701	8,983	7,099	8,546	Not reported
Total farm receipts	9,015	9,720	7,985	10,582	Not reported

XXXVI. DISTRIBUTION OF FARM EXPENSES.

Total cash expenses	4,044	5,698	2,959	4,339
Total expenses not cash	4,569	5,558	5,306	4,217
Total farm expenses	8,613	11,256	8,265	8,556

XXXVII. SUMMARY OF RECEIPTS AND EXPENSES.

Total farm receipts	9,015	9,720	7,985	10,582
Total farm expenses	8,613	11,256	8,265	8,556
Labor and management wage	402	- 1,535	- 280	2,025
Interest on investment at 5 percent	3,839	3,839	3,790	3,772
Total earnings	3,641	1,703	2,910	5,197
Interest earned	4.74%	2.22%	3.84%	6.89%

XXXVIII. EFFICIENCY FACTORS.

Crop yields per acre	1913	1914	1915	1916
Corn	42.03 bu.	25.9 bu.	50.8 bu.	51.4 bu.
Oats	35.6 bu.	39.6 bu.	51.0 bu.	26.9 bu.
Wheat	- -	22.4 bu.	- -	10.2 bu.
Rye	22.8 bu.	- -	- -	- -
Timothy and mixed hay	1.35 tons	.709* tons	2.27 tons	1.35 tons
Man labor				
Number of men	3.75	3.5	3.33	3.175
Total hours labor per man	3,089.4	3,186.5	3,025.7	3,104.17
Average daily hours per man	9.9	10.21	9.7	9.95
Cost per hour	$0.1819	$0.1651	$0.1778	$0.1702
Crop acres per man	58.1	73.7	65.3	68.84
Horse Labor				
Number of horses	13.	13.75	13.	15.
Total hours labor per horse	793.0	624.85	781.9	690.3
Average daily hours per horse	2.55	2.0	2.51	2.21
Cost per hour of horse labor	$0.152	$0.1186	$0.1685	$0.1371
Crop acres per horse	16.7	18.76	16.73	14.57

Alfalfa should be used in the regular crop rotation instead of timothy. Sweet clover forming the basis of the pasture mixture would furnish more abundant and nutritious grazing for the livestock. The average daily hours of labor per horse was too low. The crop rotation should be changed so as to give a better distribution of horse labor. It is very significant that the total crop receipts, for example, in 1916 were only $511.00 and the total livestock receipts $7,954.00. The chief animal enterprise was swine with cattle as a second major enterprise. The receipts from swine amounted to $4,770.62, in 1916, and from cattle $2,798.98. Feeder hogs and cattle are purchased in the early fall and finished for the market. The crop yields are entirely too low, but, by substituting alfalfa for timothy in the rotation and adding sweet clover to the pasture mixture and the

application of ground phosphate rock and lime stone, the yields would rapidly increase. By growing legumes both in the regular crop rotation and in the pasture mixture, the nitrogen and organic content of the soil would be maintained and probably increased.

On Farm No. 2, the total crop receipts amounted to $1,111.00, and livestock receipts to $3,338.98 in 1916. The receipts from the sale of crops on Farm No. 4 amounted, in 1916, to $816.96 and from the sale of livestock to $9,607.87. These figures show that a system of livestock farming was practiced in which practically all the crops were marketed through animals. I have discussed the results obtained upon livestock farms producing market meat and animals primarily. I wish also to discuss briefly a system of pedigreed livestock farming for the cornbelt. Pedigreed livestock farming requires a more intelligent managing ability. On the following page, I am offering a suggested plan for a 200-acre stock farm, the arrangement of the fields, buildings, hog houses, and truck patches being indicated. I have chosen a 200-acre farm partly because that more nearly approaches the average size of farms in the cornbelt and partly because pedigreed livestock farming does not ordinarily require so much farm land as producing meat animals. It is not to be inferred that a 200-acre farm is the best size for very probably more land would be better adapted to this system of livestock farming.

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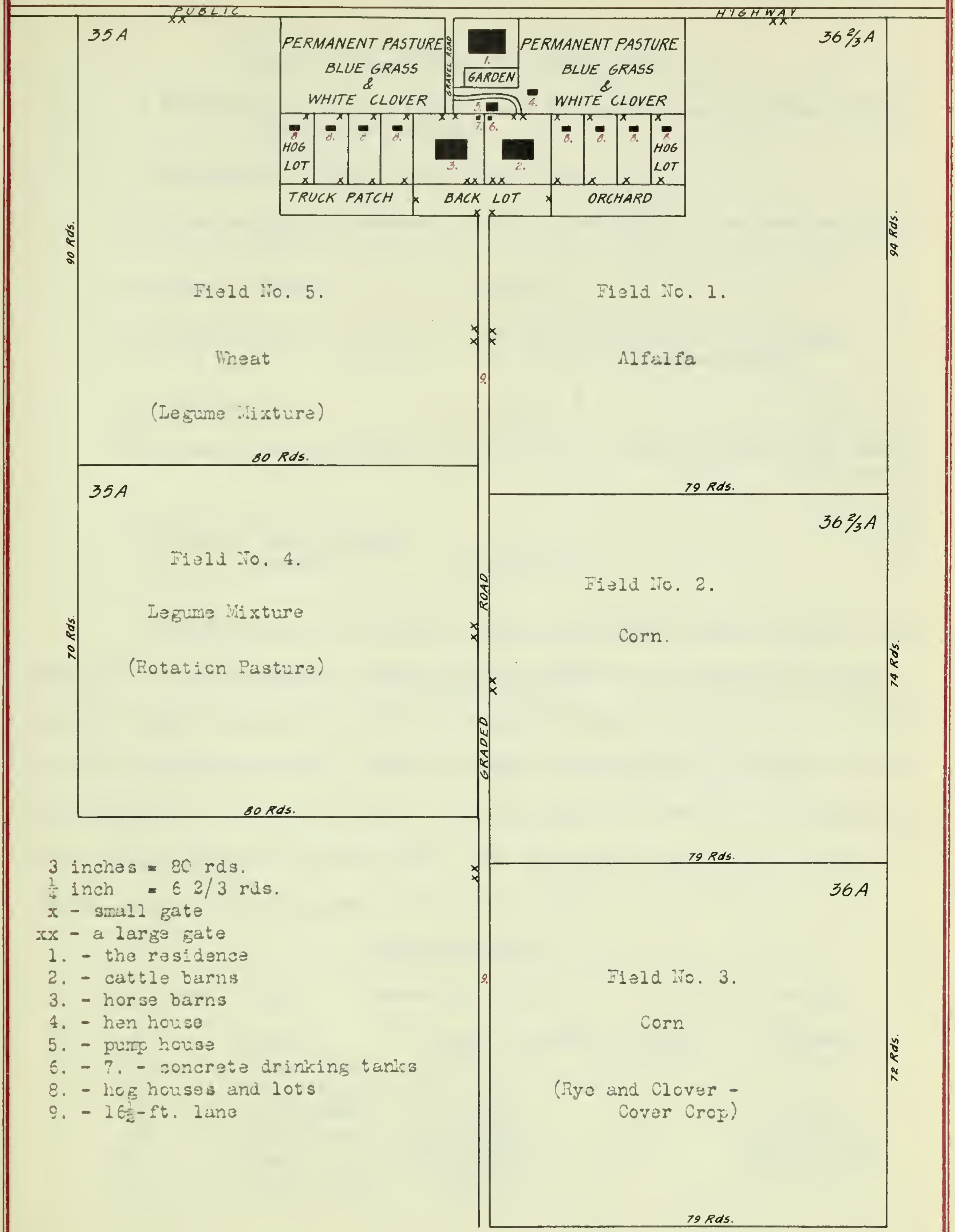

3 inches = 80 rds.
¼ inch = 6 2/3 rds.
x - small gate
xx - a large gate
1. - the residence
2. - cattle barns
3. - horse barns
4. - hen house
5. - pump house
6. - 7. - concrete drinking tanks
8. - hog houses and lots
9. - 16½-ft. lane

XXXIX. A TWO-HUNDRED-ACRE STOCK FARM

5 acres occupied by residence, horse and cattle barns, chicken houses, garden, and orchard.

5 acres devoted to hog lots, truck crops, etc.

10 acres devoted to permanent pasture consisting of bluegrass and white clover.

36 acres in alfalfa.	Field No. 1	
36 acres in corn	Field No. 2.	(24 acres for silage, (12 acres stover.
36 acres in corn	Field No. 3	
36 acres in legume mixture	Field No. 4	Rotation pasture (5# alfalfa (5# timothy (5# sweet clover (5# alsike clover
36 acres in wheat (legume mixture)	Field No. 5.	

The crop rotation consists of alfalfa five years, and a four-year rotation of corn, corn, wheat and legume mixture seeded with the wheat, and legume mixture. Every five years, alfalfa is changed to another field and corn is planted on the old alfalfa field. Wheat is seeded on second year corn land, the corn being removed for silage and stover. After the wheat is removed, the legume misture is grazed lightly the first year. The second year, the field is used for pasture, and the following year is planted to corn.

Crops produced.

No. acres	Crop	Amount per acre	Total amount
36	Alfalfa	2 tons (grazed by hogs)	72 tons
24	Silage corn	12 tons	288 tons
12	Corn stover (shredded)	1.5 tons	18 tons
48	Corn (husked)	60 bushels	2,880 bushels
36	Wheat	30 bushels	1,080 bushels
36	Wheat straw	1.25 tons	45 tons

Number of Farm Animals and Rations for each Class.

6 Farm horses (mares); average weight 1400#. Ration: (14# Corn
(12# alfalfa Hay

5 Colts (pure-bred draft fillies).
Average ration for 12 months: (4½# corn
(7⅓# alfalfa hay
(4½# oats

40 cows. Nov. 1 to May 1. Winter Ration: (30# corn silage, 3# corn
(1# cottonseed meal
(6# alfalfa hay

35 yearlings. Average weight 850#. Feeding period, Nov. 1 to May 1. Ration: (25# corn silage
(2# corn, 1# cottonseed Meal
(5# alfalfa hay.

35 yearlings. Average weight 1000#. Feed on pasture, May 1 to Sept. 1. Ration: 10# corn

12 sows. On alfalfa pasture, May 1 to October 1. Ration: 5# corn

72 pigs. Average feeding weight 175#. On alfalfa pasture May 1 to October 1. Ration: 3½# corn.

The pigs average 50# each when they are put on feed and are marketed at 300#.

12 sows. October 1 to May 1. Winter Ration: (5# corn
(4# skim milk
(4# alfalfa hay

48 pigs. Average feeding weight 175# and on feed five months, Dec. 1 to May 1. Ration: (3½# corn
(4# skim milk
(3# alfalfa hay.

130 hens. Digestible nutrients required per day for each 100# live weight for maintenance.
(dry matter 2.7
(ash .10
(protein .40
(carbohydrates 2.00
(fat .20
and nutritive ration 1 to 6.2.

Feed Consumed by Livestock Annually.

Animals	Corn	Alfalfa hay	Corn Silage	Cottonseed Meal.
6 farm horses	420 bushels	10 tons	- - -	- - -

5 colts	150 bushels	6½ tons		- - -	- - -
40 cows	385 bushels	22 tons		108 tons	3.6 tons
35 yearlings	975 bushels	16 tons		78 tons	3.0 tons
12 sows	384 bushels	5 tons		- - -	- - -
120 pigs	1,122 bushels	10 tons		- - -	- - -
130 hens	21 bushels	3 tons		1 ton	0.1 ton
Total	3,457 bushels	72½ tons		187 tons	6.7 tons
Amount produced	2,880 bushels	72½ tons		288 tons	0.0 tons
Amount purchased	577 bushels	0 tons	(Unused)	100 tons	6.7 tons

In addition to the above, 250 bushels oats were purchased for the colts, and the following feeds were purchased for the chickens:

1000 pounds chops	$12.00
225 pounds chick feed	4.10
100 pounds blood meal	3.00
200 pounds kaffir corn	2.00
100 pounds starch feed	1.15
100 pounds ground oyster shells	1.00
Total	$23.25

Capital Invested.

Amount invested in land, exclusive of buildings	$44,700
Amount invested in buildings	5,635
Amount invested in machinery	1,100
Amount invested in livestock	9,565
Total amount invested	61,000

Buildings

Amount invested in residence	$2,000
Amount invested in horse barn	1,000
Amount invested in cattle barns	1,000
Amount invested in two concrete silos (150 tons each) .	600
Amount invested in water works, house and barns	250
Amount invested in 12 hog houses, $10.00 each	120
Amount invested in implement shed and storage loft . .	205
Amount invested in hen house	100
Amount invested in work shop	25
Amount invested in outhouse and other buildings	335

Capital invested in buildings . . . . 9.2 percent

Machinery

1 gang plow	$50.	
2 three-horse plows @ $8.00	16.	
1 double gang disk harrow	30.	
1 four-section (section harrow)	16.	
1 corrugated land roller	16.	
2 wagons @ $50.00 each	100.	
2 riding cultivators @ $35. each	70.	
1 two-row cultivator	40.	
1 weeder	12.	
1 corn binder	65.	
1 wheat binder	65.	
1 small grain drill, grass attachment	35.	
1 two-row corn planter	20.	
1 mower	25.	
1 hay rake	15.	
1 hay tedder	15.	
1 hay loader	20.	
Ropes, forks, etc.	10.	
1 manure spreader	40.	
1 lime and phosphate spreader	20.	
Threshing outfit	50.	Co-operative
1 hay press	25.	Co-operative
1 feed grinder	20.	
1 buggy and harness	60.	
3 sets double harness @ $15.00 each	45.	
1 cream separator	20.	
1 set blacksmith tools	50.	
1 typewriter	50.	
Platform scales	30.	
Other machinery not mentioned	100.	
Total invested in machinery	1,100.	

Capital invested in machinery 1.8 percent.

Livestock

6 mares @ $300.00 each	1,800.
40 cows @ $150.00 each	6,000.
1 herd bull	500.
12 sows @ $100.00 each	1,200.
130 hens @ 50¢ each	65.
Total invested in livestock	$9,565.

Capital invested in livestock . . . . 15.7 percent

Labor.

1 hired man @ $35.00 per month	$420.
180 hours extra help in filling silos	36.
100 hours extra help in threshing @ 20¢ per hour	20.
200 hours extra help in baling hay	40.
100 hours extra help in haying	20.
Total cost of labor	536.

Receipts

1000 bushels of wheat @ $1.00 per bushel	1,000.00
3 registered Percheron colts @ $200.00	600.00
2 Percheron colts @ $100.00	200.00
20 registered Angus bulls and heifers @ $150.00	3,000.00
15 mixed yearlings, 1,000# each @ $9.00	1,350.00
60 registered Durocs @ $70.00 each	4,200.00
60 Durocs (pork, ave. weight 300#) @ $9.00	1,620.00
100 chickens (broilers and fryers) @ 20¢	20.00
100 pullets @ 50¢	50.00
January - 82½ doz. eggs @ 22½¢	18.43
February - 123½ doz. eggs @ 17¢	20.95
March - 169 5/12 doz. eggs @ 14¢	23.73
April - 164 5/6 doz. eggs @ 14½¢	23.90
May - 156 doz. eggs @ 14¢	21.84
June - 156 1/3 doz. eggs @ 14¢	21.89
July - 133 7/12 doz. eggs @ 17½¢	23.36
August - 108 7/12 doz. eggs @ 21¢	22.77
September - 96 2/3 doz. eggs @ 24¢	23.20
October - 89½ doz. eggs @ 25½¢	22.78
November - 66½ doz. eggs @ 32¢	21.28
December - 54 doz. eggs @ 35¢	18.90
Total receipts from all sources	$12,305.03

Expenses

577 bushels corn (purchased) @ 50¢	$288.50
6.7 tons Cottonseed meal @ $35.00 per ton	234.50
250 bushels oats @ 40¢ per bushel	100.00
Chicken feed	23.25
Expense in Angus sale	100.00
Expense in Duroc sale	200.00
Expense in marketing 15 yearlings	27.00
Expense in marketing 60 hogs	45.00
Hired labor	536.00
Depreciation and repairs on buildings	150.00
Depreciation and repairs on machinery	75.00
Kerosene and gasoline for threshing, etc.	75.00
Horseshoeing	5.00
Breeding fees, 5 colts @ $15.00 each	75.00

Insurance	$50.00
Taxes	300.00
Seed for legume mixture @ $3.50 per acre	125.00
Seed for seeding alfalfa field	25.00
72 tons lime stone @ $2.00 per ton	144.00
18 tons of ground phosphate rock @ $7.50 per ton	135.00
Fences and repairs	50.00
Miscellaneous expenses	100.00
Total expenses	$2,863.25

Summary

Average capital	$ 61,000.00
Receipts	12,305.03
Expenses	2,863.25
Income from capital and operators' labor	9,441.78
Interest on capital at 5%	3,050.00
Labor income	6,391.78

The wheat straw is used for bedding and for covering the wheat land in winter. The 100 tons of corn silage left over from winter feeding is used to supplement the pasture in summer. Also shredded corn stover is used for supplementing the other feeds and the refuse stover for bedding.

Corn stalks on first year corn land are cut up thoroughly and the land broken, preferably in the fall, for corn the following spring.

All manure is carefully saved and returned to the land. The manure is applied in the regular crop rotation to corn land and winter dressing the wheat. Ground limestone, at the rate of two tons per acre, together with 1000 pounds of finely ground phosphate rock is applied once every five years, both minerals being applied just ahead of seeding to alfalfa.

XL. SYSTEMS OF LIVESTOCK FARMING FOR THE WEST

The most successful type of farming for the West is a combination of wheat, as the major cash crop, alfalfa, colts, cattle, sheep, swine, and poultry. The climate and soils in the West are admirably adapted to wheat and alfalfa. The very fact that alfalfa has spread over such a great area of the West is proof

of its adaptability to that great region. It was introduced into California about 1850 and has spread from there throughout practically all the western states. Kansas alone, in 1910, had 956,000 acres in alfalfa. In this section, alfalfa should be raised for both the hay and seed. For grazing purposes, it would be advisable to mix sweet clover with alfalfa as sweet clover also grows well in this section and will stand more grazing. Livestock of all classes can be wintered very satisfactorily on alfalfa and oat or wheat straw.

In the dry farming sections of the West, the sorghums are largely used in the crop rotation. The sorghums are adapted to semi-arid regions because of the following:

(1) They require less water to produce a pound of dry matter. Corn requires about 368 pounds water to produce a pound of dry matter, and sorghums about 306 pounds.

(2) Better able to protect themselves from evaporation. Leaves roll up.

(3) Sorghums have twice as many lateral roots as corn.

(4) Growth may be checked for some time without serious loss.

Livestock should be kept in this section to utilize the rough lands, and to consume the roughage and other waste products on the farm.

XLI. SYSTEMS OF LIVESTOCK FARMING FOR THE SOUTH.

The South is blessed with a mild climate and a long growing season. There is an abundant rainfall, being 40 to 60 inches annually, for the production of maximum crops. The soil and climate are adapted to the growing of a great variety of crops. The soils are generally deficient in nitrogen and organic matter, but, when these are added by turning under legume crops or by the application of manures, crop yields are greatly increased. It will be remembered that the record acre yields of corn have been made in the south rather than in the cornbelt. There are numerous substantuated reports of yields of more than 225 bushels of corn per

acre. These yields show the possibility of corn production in the south when the limiting elements of plant food are supplied together with organic matter. The annual winter legumes such as crimson clover, burr clover, and hairy vetch are well adapted to all the soil types, and can be fitted into the crop rotation, being seeded in the cotton or other fields at the last cultivation. The annual summer legumes such as cowpeas, soybeans, and velvet beans also fit well into the regular crop rotation, being seeded with the corn in the same drill or in alternate rows. Alfalfa, sweet clover, mammoth clover, red clover, alsike, and white clover grow well in practically all sections of the south where there is sufficient calcium in the soils. Where the soils are deficient in calcium, ground limestone can be added at small cost per acre. No other section in the United States can grow such a variety of legumes and pasture grasses, and this together with a long pasturage season, abundant rainfall, short and mild winters make the south an almost ideal livestock section. The crop rotations should contain both summer and winter legumes, and the rotative pasture should contain some high yielding legume such as sweet clover, alfalfa, or lespedeza. The following rotations with slight changes to meet special conditions will be found well adapted to the different sections of the south:

Crop rotations for southern Texas, Louisiana, Mississippi
Alabama, Florida, Georgia, and South Carolina.

Rotation No. 1.- A four-year rotation.

Field No. 1 - Corn and velvet beans planted in the same drill. Soybeans or cowpeas in alternate rows. Corn to follow cotton.

Field No. 2 - Cotton. Bur clover alone or bur clover and rye (abruzzie rye) seeded in the cotton middles - September 20 to October 1.

Field No. 3 - Rotative pasture. Pasture mixture consists of lespedeza and herds grass. The pasture land should be broken the first of October and seeded to rye. The following spring,

the rye should be disked thoroughly in preparation for cotton.

Field No. 4 - Oats. Oats follow corn, and should be sown from October 1 to November 15. Lespedeza and herds grass seeded in the oats January 15 to February 15. The herds grass can be seeded with the oats in the fall.

After the oats are removed from Field No. 4, the lespedeza and herds grass will make a good crop which is used for hay. The following year, this field is used for pasture. The above is an excellent rotation for the thin to medium lands.

Rotation No. 2. A five-year rotation - corn, cotton, pasture, alfalfa, and oats.

Field No. 1.- Corn and velvet beans in the same drill. Soybeans or cowpeas in alternate rows. Corn to follow cotton.

Field No. 2 - Cotton. Bur clover and rye as a cover crop, being seeded in the cotton middles September 20 to October 1.

Field No. 3 - Pasture. Sweet clover is seeded among the alfalfa, which has been used one year for meadow, October 1.

Field No. 4 - Alfalfa. The alfalfa is seeded with the oats, and the first year is either grazed lightly or used for hay. The following year it is cut for hay. In the fall of the second year, ordinarily about October the first, alfalfa is cultivated with an alfalfa cultivator and sweet clover seeded with it, and the third year it is used for pasture.

Field No. 5 - Oats. Oats follow corn and should be sown October 1 to November 15. Alfalfa should be seeded with the oats. After the oats are removed from the land, this field can be used for pasture or hay. The next year it is used for hay and the third year for pasture.

The above is an excellent rotation for the better class of clay soils of the far south.

Crop rotations for central Texas to northern sections of Louisiana, Mississippi, Alabama, Georgia, North Carolina, and South Carolina.

Rotation No. 1. A four-year rotation - corn, cotton, oats, and pasture.

Field No. 1 - Corn and velvet beans or cowpeas in the same drill. Soybeans in alternate rows. Rows three feet apart. Corn follows cotton.

Field No. 2 - Cotton. Bur or crimson clover and rye or oats or barley sown in the cotton middles September 15 to October 1. Cotton follows pasture.

Field No. 3 - Pasture. Pasture mixture can be either lespedeza and herds grass or red clover and orchard grass.

Field No. 4.- Oats. A few acres of wheat for home use may be substituted for oats. The lespedeza and herds grass should be seeded among the oats February 1 to 25. If red clover and orcharc grass are preferred, they may be seeded with the oats from September 1 to October 25.

The above rotation is adapted to the thin to medium sandy and clay soils.

Rotation No. 2. A five-year rotation. - corn, cotton, rotation pasture, oats and alfalfa.

Field No. 1 - Alfalfa. Alfalfa is grown on this field for five years, and then it is changed to another field.

Field No. 2 - Pasture. The pasture mixture consists of sweet clover with about five pounds of orchard grass added.

Field No. 3 - Oats. Sweet clover and orchard grass sown with the oats in the fall. Used for pasture the second year.

Field No. 4 - Cotton. Bur or crimson clover and rye or oats or barley sown in the cotton middles as a cover crop.

Field No. 5 - Corn and velvet beans or cowpeas in the same drill. Soybeans in alternate rows. Corn follows cotton.

Every sixth year alfalfa is changed to another field, being seeded on

pasture land. Cotton then follows alfalfa, and corn follows cotton as before.

The following rotations are suggested for Oklahoma, Arkansas, Tennessee, Kentucky, Southern Virginia, and Northern North Carolina.

Rotation No. 1 A four-year rotation - corn, cotton, oats and wheat, and pasture.

Field No. 1 - Corn and soybeans in the same drill or corn and soybeans in alternate rows. Corn to follow cotton.

Field No. 2 - Cotton. Bur or crimson clover, and wheat or barley, as a cover crop, seeded in the cotton middles from August 10 to September 15. Cotton to follow pasture.

Field No. 3 - Pasture. Pasture mixture to consist of:
(1) Lespedeza and herds grass.
(2) Red clover and orchard grass.

Field No. 4 - Oats and wheat. One-half of this field sown to oats and the other half sown to wheat. Lespedeza and herds grass or red clover and orchard grass sown with the oats and wheat. Oats should be seeded September 10 to 25, and wheat October 1 to 20.

Oats and wheat follow corn. The first year after oats and wheat are harvested, the field may be used for grazing or for meadow which is the best practice. The following year, this field is used for pasturage.

Tobacco may take the place of cotton, in sections growing tobacco, with the rest of the rotation the same. This would make the rotation consist of corn, tobacco, oats and wheat, and rotation pasture.

A five-year rotation of corn, cotton or tobacco, rotation pasture, oats and wheat, and alfalfa may be used. This is the same as rotation No. 2 on page 67 except that Field No. 3 in this rotation is planted to oats and wheat, oats being planted on half the acreage and wheat on the other half.

In any of the above rotations, part of the corn land can be used for growing silage corn. For producing silage, corn and sorghum should be drilled together as better yields can be obtained by this method. Rough lands not suitable

for cultivation should be put in permanent pasture. The pasture mixture for lime soils should be sweet clover and orchard grass. On the thinner sandy soils of the extreme south, bermuda grass, lespedeza, white clover, and bur clover make an excellent mixture for permanent pasture. In other sections further north, lespedeza, white clover, and alsike clover make a good pasture mixture. In Kentucky, bluegrass and alsike or white clover make a good pasture. In sections where it grows well, sweet clover pasture is very excellent as it makes a luxuriant growth which is rich in protein and calcium. Most soils in the south are deficient in calcium and phosphorus, and under a system of livestock farming it is especially necessary to have abundance of these two elements in the soil. They can be most economically supplied by applying ground lime rock at the rate of two to three tons per acre, and ground phosphate rock at the rate of 800 to 1200 pounds per acre once in five years, both being applied ahead of the legume in the regular crop rotation. The crop rotations should be combined with raising colts, cattle, sheep, swine, and poultry. With such a great variety of legumes and pasture grasses together with abundant rainfall and a long growing season, the south is admirably adapted to the economic production of all classes of livestock, and with the proper development, the south will become one of the leading livestock sections of the United States.

The future systems of livestock farming in the United States will be a combination of good crop rotations and livestock production. The crop rotations will vary for different sections depending largely upon the character and adaptability of soils for producing crops, climatic conditions, and available markets. The rotation should contain some profitable cash crop such as corn, cotton, wheat, tobacco, or other crop, and one or more heavy yielding legume crops such as alfalfa or sweet clover combined with livestock production.

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